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ALTGELD HALL STACKS

PRELIMINARY REPORT

OF THE

UNITED STATES NATIONAL WATERWAYS COMMISSION

PRESENTED BY MR. BURTON

January 24, 1910.—Ordered to be printed

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PRELIMINARY REPORT UNITED STATES NATIONAL WATERWAYS COMMISSION.

The National Waterways Commission, composed of twelve members of the Senate and House of Representatives, was created by act of Congress of March 3, 1909. The duty imposed upon it by statute was to investigate questions pertaining to water transportation and the improvement of waterways, and to make recommendations to Congress.

The commission has had under consideration the topics assigned to it, and has held numerous meetings, both in the United States and Europe. Seven of the twelve members took a somewhat extended tour for the examination of European waterways in the months from August to October last. In addition, a majority of the members of the commission examined the Mississippi River from St. Paul to New Orleans in November, 1909, and some of them also, during the same month, inspected the Missouri River from Kansas City to its mouth, and the Illinois River from its lower portion up to the head of navigation. It may be added that the commission includes in its membership Senators or Representatives who at different times during the last ten years have examined nearly all of the waterways of the United States. Consequently its members are enabled to bring to the consideration of the problem a very considerable familiarity with the waterways both of the United States and of Europe as well. The commission has been aided in the course of its investigations by officials detailed from the War and Navy departments, and has obtained the assistance of other experts in waterway transportation. In the framing of this report, especial aid has been rendered by Rear-Admiral C. S. Sperry, of the Navy Department; Col. W. H. Bixby, and Maj. F. A. Mahan, retired, of the Corps of Engineers, U. S. Army; and also by Prof. Frank H. Dixon, of Dartmouth College, and Mr. E. O. Merchant, of Columbia University. Numerous inquiries have been sent to commercial bodies and waterway improvement associations, most of which have met with a cordial response. The officials of European countries, in which waterway systems have been developed, and our consuls abroad, have rendered generous aid in the furnishing of material and in affording suggestions.

Under the statute creating the commission, it was provided that a preliminary report should be filed not later than January 1, 1910, containing conclusions reached by the commission upon the several subjects investigated. Unavoidable conditions have caused a few days' delay.

The commission now presents its preliminary report. In reaching conclusions upon the specific items set forth in the statute creating the commission, it has been deemed necessary to report also upon

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It has been impossible to give such elaborate and careful investigation as the members desire to all of the questions pertaining to waterway improvement. In a later report it is intended that further recommendations will be made, and such additional material as may be collected will be filed with Congress. The conclusions presented express the unanimous opinion of all the members of the commission, except in one instance, as set forth on page 11.

Several articles prepared by Messrs. Sperry, Bixby, and Merchant, mentioned above as assistants to the commission and by others, are attached as appendices. Some of these are statistical merely. These appendices are regarded as of very substantial value, although the commission expresses neither approval nor disapproval of the views therein set forth.

In reaching its conclusions, the commission has separately considered the following distinct topics:

First. The reasons for decline in inland waterway transportation, together with suggested remedies therefor, and the relation between waterway and railway transportation.

Second. Canals, including especially the advisability and practical value of canals for deep-draft vessels.

Third. The necessary steps to be taken before the adoption of projects for the improvement of rivers and harbors, and the method of making appropriations therefor.

Fourth. The proper division between appropriations by the Federal Government on the one hand and the States, minor political divisions, and individuals on the other.

Fifth. The relation of waterway improvements to bank protection, flood and drought prevention, irrigation, and drainage.

Sixth. The most desirable policy relating to harbors, including the ownership and control of wharves and docks.

Seventh. The relation of waterway improvements to water power.

Eighth. Methods for the improvement of rivers, including the construction of locks and dams.

Ninth. Comparison of European waterways with those of the United States, including an investigation of European and American transportation rates both by land and by water.

I.

THE REASONS FOR DECLINE IN INLAND WATERWAY TRANSPORTATION, TOGETHER WITH SUGGESTED REMEDIES THEREFOR, AND THE RELATION BETWEEN WATERWAY AND RAILWAY TRANSPORTATION.

The commission has had under consideration the manifest decrease in water-borne traffic on a majority of the rivers and inland waterways of the country.[a] On many there has been an absolute decrease, while on others the falling off has been merely relative. In these latter cases, although the aggregate traffic by rail and water has been greatly multiplied, the proportional share carried by water has very noticeably diminished. Perhaps the most striking illustration of this is the traffic of the Erie Canal. In 1880 this canal carried between Buffalo and New York 4,608,651 tons, or 18 per cent of the total traffic, while in 1906 (the latest year for which statistics are available) the canal carried only 2,385,491 tons, or 3 per cent of the total traffic, as against 78,703,315 tons transported by the New York Central and Erie railways. Not only has the actual traffic on the canal decreased nearly 50 per cent since 1880, but the relative amount carried by the canal, as compared with the two railroads, has fallen off from 18 per cent to 3 per cent. Likewise, on as important a river as the Hudson, the local river commerce, exclusive of what comes through the Erie Canal, has shown a considerable decline. The commercial statistics of the army engineers for the section of river between Coxsackie and the state dam at Troy show a falling off from 4,045,895 tons in 1898 to 2,945,921 tons in 1908. On a number of southern rivers also, such as the Altamaha, Tombigbee, and Pearl, there has been a marked decline in river traffic.

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[a] The most reliable statistics relating to water-borne traffic are to be found in the Census Report on Transportation by Water, 1906, published in 1908; Report of the Commissioner of Corporations on Transportation by Water in the United States, 1909; and the annual reports of the Chief of Engineers to and including 1909. The commission has also examined numerous reports of chambers of commerce and trade bodies. See also Preliminary Report, Inland Waterways Commission (1908), pages 35 to 176.

Quite as striking is the decrease in traffic on the Mississippi River and most of its tributaries. The following figures emphasize this fact:

Freight shipments, Mississippi River system, for 1889 and 1906.

[Compiled from Census Report, Transportation by Water 1906, p. 181.]

	1906.					1889—total tons.	Change since 1889.	
	Self-propellers.		Barges and tows.		Total tons.		Gain.	Loss.
	Tons.	*Per cent.*	*Tons.*	*Per cent.*			*P. ct.*	*P. ct.*
Upper Mississippi	153,932	25.8	441,953	74.2	[a] 595,885	[a] 3,947,364	......	85
Illinois River	32,764	31.0	73,062	69.0	105,826	180,264	......	41
Missouri River	84,790	8.2	952,269	91.8	1,037,059	2,132,820	......	42
Other tributaries above St. Louis	1,876	9.7	17,455	90.3	19,331			
Total upper river system	273,362	15.5	1,484,739	84.5	1,758,101	6,260,448	......	72
Ohio River system	1,246,437	8.2	13,980,368	91.8	15,226,805	15,796,968	......	3
Lower Mississippi system	835,587	32.8	1,710,600	67.2	2,546,187	6,232,087	......	59
Total Mississippi system	2,355,386	12.1	17,175,707	87.9	19,531,093	28,289,503	......	31

[a] These figures do not include ferry traffic at St. Louis.

Other tables furnished by the Department of Commerce and Labor, classifying these shipments by commodities, show that the main items of decrease have been logs and lumber, ice, grain, coal, iron ore, and general merchandise on the upper Mississippi River system, and grain, lumber, cotton, and general merchandise on the lower Mississippi River system. The decline in the rafting of logs and lumber is responsible for a considerable share of the decrease shown.

On the other hand, the traffic on the Great Lakes has increased enormously. The total commerce passing through the Sault Ste. Marie Canals, where very accurate statistics are collected, amounted to 3,256,628 tons for the season of 1885, 21,234,664 tons for 1898, while for 1908 it had increased to 41,390,557 tons, and for 1909 to 57,895,149 tons. Increased channel depth and lock facilities have been provided from time to time to meet the increasing traffic. It should be stated, however, that the Great Lakes are in a class by themselves. Likewise on some rivers, such as the Monongahela, the Kanawha, and a number of minor streams, the traffic has shown a considerable increase. On the Ohio River the aggregate tonnage has been well maintained, also on portions of the Tennessee it has shown some increase. A notable feature of the traffic upon some rivers has been the development of transportation for short distances, including ferry traffic.

The most frequent argument for river transportation has been that for coarser freights over long distances water transportation afforded very great advantages. There can be little question of the general accuracy of this statement. A boat or barge floating in the water is readily moved and at low speeds requires far less power than the movement of a railway car or other receptacle for freight used on land. The general statement has been made and widely accepted that with an equal expenditure of power about five times as much freight can be handled by water as by rail. The expense of equipping a transportation line, at least so far as the boats are concerned, is but trivial in comparison with that of constructing a railway. River transportation again has a decided advantage in that the waters are free, and anyone having the requisite capital and ability can engage in the business. This tends to create competition and to prevent monopoly. Indeed, it may be asserted as a general proposition that in any highly advanced country it is extremely desirable that an abundance of transportation facilities be furnished and that means be afforded for the carriage of freight not only by rail, but by water as well. It is a matter of common occurrence that in years of great crops or unusual prosperity the railways of the country have been unable to provide for the prompt and efficient performance of their duties as common carriers. The existence of this condition affords an independent argument for the development of transportation routes by water, even in localities where shippers mainly depend upon railways.

It has been the aim of the commission to find the explanation of the marked tendencies which have become manifest in the diminished use of most of the inland waterways of the country, and, if possible, to point out certain remedies.

It is the opinion of the commission that the most important factor in the decrease of water-borne traffic alongside of and contemporaneously with the great increase in railway traffic is due to the relations existing between these two great agencies for transportation.

The many advantages which a railway has in competition with a water route may be grouped into two general classes.

1. Those inherent or fundamental advantages which are based upon permanent conditions.

The first and most important of these is the wider area of distribution available to railways. A railroad line can be constructed in any direction to any part of the country except the portions which are admittedly inaccessible, while the line of a river is fixed by nature in a single direction. Railroads are more readily adaptable to the newly arising and ever-shifting demands of producing areas and of markets. In providing for the receipt and delivery of freight at factories or warehouses, branch lines or switches can be constructed. Railroads can reach all cities and towns alike, whether located upon the water or not, while obviously boats or barges can not be used except for the receipt and delivery of freight or passengers from or to localities upon waterways. The rapid growth of inland cities not located upon waterways, many of which have attained very considerable size, emphasizes the possibility of development where the dependence for transportation facilities must be upon railroads alone. Notable illustrations of such prominent centers are Birmingham, Ala.; Atlanta, Ga.; Columbus, Ohio; Indianapolis, Ind.; Denver, Colo.; and a great number of cities and towns which are not provided with facilities for water-borne traffic.

A second advantage of the railways, which can be counted as belonging to this class, lies in the increasing importance of terminals and the necessity for facilities for the prompt and economical loading and unloading of freight. The cost of hauling freight, as compared with the handling or delivery at terminal points, has experienced a great change in the last forty years. The cost of hauling has very materially decreased, while the cost of handling and the expenses connected with terminal facilities, though diminished in many ways, have not decreased accordingly.

A third advantage in this class is intimately associated with the preceding, and arises from the readier transfer of traffic from one railway to another, as compared with transfer from water to land or land to water. This includes not only physical transfer of traffic, but the through haul of cars without break of bulk and a thorough organization for through billing over various roads, with facilities for easy settlement of joint accounts of the cooperating railways. In this connection may be mentioned a physical disadvantage of rivers, due to the very considerable oscillation in their levels. This fact makes it more difficult to provide convenient and adequate loading machinery and renders the receipt and shipment of freight proportionately more expensive. The variation in the Ohio River at Cincinnati is over 60 feet; that of the Mississippi at Grafton, Ill., below the mouth of the Illinois River, is 29.6 feet; at St. Louis, 43.92 feet; below Cairo and the mouth of the Ohio River, 45.6 feet; between Memphis and Helena, Ark., 54.75 feet; at Vicksburg, Miss., 58.98 feet; and at New Orleans, La., 21.02 feet.

Another consideration is that railways, as a rule, make a higher speed per hour and the distance to be traversed between terminals is usually shorter by rail. Furthermore, the railway is more reliable in its schedules. It should, however, be stated that on certain water routes in this country, especially in seasons of traffic congestion, freight is quite as promptly delivered, and in many instances more promptly, than on railways.

2. Those advantages pertaining to railways which may be deemed artificial or temporary. These are due to conditions not necessarily permanent in their nature.

The first and most important of these is the right of the railway to charge lower rates between points where their line is in competition with water routes.

Section 4 of the Act to Regulate Interstate Commerce contains the following provision:

> That it shall be unlawful for any common carrier subject to the provisions of this act to charge or receive any greater compensation in the aggregate for the transportation of passengers or of like kind of property, under substantially similar circumstances and conditions, for a shorter than for a longer distance over the same line, in the same direction, the shorter being included within the longer distance.

The words "under substantially similar circumstances and conditions" found in this section have been interpreted to mean that the existence of actual water competition constitutes a circumstance sufficiently dissimilar to relieve the carrier from the operation of the law. Under this interpretation the cutting of rates, where water competition exists, has been carried to an almost unlimited extent. It is now a question whether the right to lower competitive rates has not been exercised to an extent much in excess of what was intended when the act was passed, and, it may be added, to a degree quite inconsistent with the most salutary policy for the commercial and industrial interests of the country.

A second of these artificial or temporary advantages of the railroads comes from the power to acquire steamboat lines or enter into agreements with them for the purpose of stifling water-borne traffic, either by operating the steamboat lines or by discontinuing their use upon competitive routes. In both methods, namely, in the acquisition and operation of steamboat lines in such a manner as not to compete with railways, and in removing them entirely from the field of competition, the railway companies of the country have been very active.

A third advantage arises from the refusal to pro-rate on through routes where naturally freight would be carried part of the way by rail and part by water. In many cases the route, which apparently is the natural one, would be by water for three-fourths or more of the distance, yet the charge for the remaining railway haul is so considerable as to render carriage for the longer haul by water unprofitable.

A fourth advantage of the railways, in this class, is the far greater attention given to provision for warehouses, terminals, and the equipment for handling freight. On many of the waterways very little if any progress has been made during the last fifty years in furnishing modern facilities for the storage or handling of traffic. In each of a considerable number of cities located upon rivers and canals in Germany the members of the commission during their recent inspection trip saw a larger investment for terminals and for the storage of freight and handling of boats than exists on the whole of the Mississippi River above New Orleans.

It is to be noted that in localities where water-borne traffic has increased, as on the Great Lakes, careful and elaborate provision has been made for the handling of freight in the most economical manner. It is not, in the opinion of the commission, difficult to explain the remarkable increase in this locality. Upon the Great Lakes there is a demand for the shipment of freight unsurpassed anywhere. The great iron-ore mines of the upper lakes and the very large quantities of grain awaiting shipment toward the more populous regions of the Atlantic seaboard and for export to Europe, as well as the quantities of lumber, which, though greatly diminished, are nevertheless considerable, afford cargoes for the downward trip, while the great demand for coal in the territory tributary to the upper lakes and the great supplies near to Lake Erie afford a return cargo which, though relatively much less in volume, is still very large. The equipment for the loading and unloading of freight at terminal points is more advanced than anywhere else in the world. The boats are constructed with a view to utilizing space, so that a given tonnage will carry the greatest possible load, and those carrying the larger part of the traffic are specially constructed with a view to rapid loading and unloading of their cargoes. On the Great Lakes there are, moreover, channels of 20 feet on through routes, with an equal depth in the large harbors. Notwithstanding the immense traffic on these lakes, it is, however, a noticeable fact that the quantity of general merchandise or package freight has not kept pace with the far more rapidly increasing traffic in the staple articles—iron ore, coal, grain, and lumber. It is estimated that not more than 5 per cent of the total traffic on the lakes is made up of materials other than those mentioned. The traffic in these staples passing through the Sault Ste. Marie Canal in 1907 included 97½ per cent of the total.

On the Monongahela River, which, next to the Great Lakes, affords the most striking illustration of the growth of inland waterborne traffic, coal mines are located at or very near to the river, and these supply a part of the almost unlimited quantity demanded for fuel in the mills and furnaces in or near to Pittsburg. This coal is readily loaded from the mines into boats or barges and from them directly discharged to the mills or furnaces where required. About one-third of the coal moves beyond Pittsburg to points on the Ohio and Mississippi rivers.

On a number of minor streams, such as the tributaries of the Delaware, traffic has been well maintained by established boat lines which have been in existence for a very long time. One great advantage possessed by these streams is the possibility of delivering freight to towns not provided with railway transportation. Also, in some instances, there is a very considerable saving in distance.

In still another class, traffic, though not so well maintained, continues to be large, as on the Penobscot and Kennebec rivers, to points upon which freight and passengers are carried by boats running from Portland or Boston, also on the Connecticut River, where the city of Hartford has a daily line to New York City. Such water routes involve a combination of river and coastwise traffic and are frequently able to provide for the delivery of freight more promptly than by rail.

It has repeatedly been urged that rivers should be improved because of the tendency of such improvements to lower railroad rates. This tendency can not be denied. It is very manifest in every portion of the country where rivers have been improved; and so considerable has been the effect that it has frequently been argued that even if a river channel should not be used at all, it would be profitable to expend money upon it solely for the effect upon rail rates. The commission, while fully recognizing this fact, can not indorse this as a desirable policy to adopt. It rests, in the first instance, upon the transparent fallacy that the railways constitute an intrenched and uncontrollable monopoly which can not be reached by legislation or other orderly and legal methods; that the only way in which to compel them to lower rates is by the expenditure of large sums of money in the improvement of channels, which are to remain wholly or partially unused. National or state legislation is certainly sufficient, and should be resorted to for securing proper reductions in railroad freight rates. Again, the subject of transportation should be considered as a great economic problem. The cost of facilities for carrying freight, whether borne by the Federal Government or by private capital, is a burden upon the resources of the country. While the tendency of waterway improvements to lower freight rates is an important element to be considered, the fundamental criterion should be whether a railway or waterway, when constructed or improved, will be a profitable investment of capital.

As regards remedies to overcome the second general class of advantages of railways over waterways, those designated as artificial or temporary, the commission has considered a great variety of propositions. It has been brought to our attention that in a number of instances railways have temporarily reduced rates and continued them upon a lower basis until competing water lines have been driven out of business. The commission would recommend that in such cases, when a rate is once reduced by a railway, it should not be permitted to raise the same unless, after hearing by the Interstate Commerce Commission, or other competent body, it should be found that such proposed increase rests upon changed conditions other than the elimination or decrease of water competition.

The most essential requirement for the rehabilitation of water traffic is, in the opinion of the commission, the establishment of harmonious relations between railway and water lines. It is quite as important that there should be cooperation between them as that greater depth of channels should be secured. A study of the water routes which are found to be profitable in the United States discloses the fact that in practically every case the boats upon them are operated in connection and in harmony with railway lines, and, on the other hand, many railways utilize boat lines either actually owned by, or operated in harmony with, them to their very great benefit. It thus appears that to an extent this cooperation already exists, and the transportation facilities of the country will, as we believe, be still further promoted by compelling joint rates and prorating agreements; also by requiring through bills of lading and physical connection between rail and water agencies. It is a waste of capital to construct separate systems of warehouses and terminals for railroads and waterways when they can be used jointly by both methods of transportation. Legislation, in order to be effective, must require terminal and wharfage charges to be reasonable whether these facilities are owned by railways or waterways.

There are many advocates of legislation which would give the Interstate Commerce Commission the power to prescribe minimum rates for railroads. Such legislation would rest upon the theory that the lowering of rates as a general proposition oftentimes operates merely for the benefit of a favored few who are able to take advantage of them, and that, applied to railroads, the exercise of such a power would prevent that ruinous competition between rail and water routes which drives the boats off the rivers and canals of the country. In France there is a fixed rule that there shall be a difference in rates of 20 per cent in favor of the waterways, and in case railways in competition with waterways desire to fix lower charges for the carrying of freight, application must be made to a commission which invariably refuses permission if water transportation would in any way be prejudiced or placed at a disadvantage.

The commission can not see its way clear to recommend a general power to fix minimum rates. In the development of the country a lowering of the cost of transportation is an important factor in promoting industries and commerce. The general tendency has been toward lower rates, and any regulation which would directly or indirectly interfere with this tendency would probably be injurious rather than otherwise. A majority of the commission, however, would recommend giving the power to the Interstate Commerce Commission to prescribe minimum railroad rates whenever, in its opinion, the object of a railroad in reducing rates is to destroy waterway competition.

In dwelling upon the disadvantages of waterways we do not omit to mention the handicap which has existed on numerous rivers because of the delay of the Government in prosecuting projected improvements. This delay operates as a disadvantage, because those who contemplate the building of boats and the establishment of steamboat or barge lines are unable to proceed with confidence. On the other hand it should be said that the danger of ruinous railway competition is a far more serious obstacle to the development of waterway traffic. Under this competition many channels which afford ample depth and the opportunity for the economical shipment of freight have remained largely in disuse. The criticisms upon the policy of Congress because the development of water routes has not been prosecuted with greater rapidity fail to take into account the substantial facts which have in the past discouraged the development of river transportation.

Mention must also be made of the fact that in numerous instances, although appropriations for the improvement of channels have been sufficiently large to create a high degree of efficiency for purposes of navigation, the use of the improved channels has not been at all commensurate with the expense incurred, one reason being a noticeable lack of progressiveness in providing suitable boats or other means of conveying freight, and another, the failure to provide terminals having modern equipment and facilities.

No improvement by the Federal Government will suffice without the cooperation of communities and business interests upon which reliance must be had for the proper utilization of improved waterways.

It is advised that by legislation, and in every way possible, cooperation be also secured between rail and water routes. Especially where such cooperation can be secured, or suitable railroad service does not exist, the commission would recommend the improvement of waterways, which, on expert examination, are found to be profitable investments of capital and will be of economic value as a means for transportation. Such improvement, it is believed, will greatly promote general commerce and the development of the industries of the country.

In the course of their investigations the members of the commission have observed the lack of comprehensive statistical information upon inland waterway traffic. In some localities, as at the locks at Sault Ste. Marie, detailed statements are carefully prepared under the direction of the Army Corps of Engineers, giving the quantity and quality of the freight and the number of passengers carried through the locks. Other reports made by the Corps of Engineers afford valuable information, though, in some instances, incomplete.

Available statistics are furnished by several different bureaus of the Government, but are strikingly lacking in uniformity and in sufficient classification as well. The terms "general merchandise," "miscellaneous merchandise," "unclassified freight," "package and packet freight" are used in the same general sense, though quite ambiguously as to what categories of freight are included.

It is recommended as desirable that a uniform system be established applicable to all waterways, under which statistics may be collected showing the volume and different kinds of traffic carried on the rivers and inland channels of the country. This will not only be valuable in affording suggestions as to the extent to which waterway traffic is increasing or diminishing, and thus assist in determining the legislative policy to be pursued, but will also afford information of very considerable service to the commercial interests of the country. It is to be noted that we are far behind several countries of Europe in the accuracy of statistics relating to inland navigation. It is desirable that the statistics should show not merely the number of tons carried and the money value of the same, but the distances over which commodities are transported, so that not only the number of tons carried may be ascertained, but the ton mileage as well. In many respects statistics of the latter are more valuable than of the former. In some instances ferry traffic which is carried a half mile or less is placed upon the same footing with traffic carried a thousand miles or more.

It is a question of detail for Congress to consider what agency shall be intrusted with the collection of these statistics. It is thought that the necessary information can be obtained by the expenditure of a comparatively trivial sum of money, and the duty may be imposed upon existing bureaus and officials, such as the army engineer corps, the collectors of customs, where the navigable channels are near to custom houses, and those engaged in the Steamboat-Inspection Service. Rules requiring masters or owners of boats to report the quantity of freight and the distance it is carried should be enforced.

The commission would also call attention to the desirability of more extensive information regarding the high-water, low-water, and average-water discharge of the various rivers of the country. Information of this kind has been collected for some time on the Mississippi River from its source to its mouth. Fairly accurate statistics are already available for the high and low water depths of this and other streams, but in addition to this it is recommended that statistics be collected and made available for the high and low water discharge. This will require a more extended examination of cross sections and velocities at typical places. Accurate information upon these points is necessary in order to frame and execute properly devised plans for river improvement. The cooperation of commercial bodies in furnishing statistics should be encouraged.

II.

CANALS, INCLUDING THE ADVISABILITY AND PRACTICAL VALUE OF CANALS FOR DEEP-DRAFT VESSELS.

Many advocates of the building of canals manifestly fail to take into account the very great advantage of natural waterways over artificial channels for purposes of navigation. Natural waterways have banks which have been formed through an unlimited time and are adapted to the flow of water between them. Save in arable soils, the banks have a certain degree of stability and operate as a bulwark against the wash or swell created by the passage of boats. Natural waterways pass through valleys and usually close to large and populous communities which have been located and developed in former days largely because of river transportation facilities. They are available for the passage of boats, and possess extra width at many places, by reason of which the development of docks and basins is much facilitated without extra cost for right of way. For a large portion of each year, during the high-water season, they allow the passage of boats of unusual draft.

Artificial channels may be constructed along a straighter line, but usually with great difficulties in the acquisition of property for their construction, as well as in the overcoming of differences in elevation; and topographical conditions may cause the route not only to pass at a distance from the existing large and populous communities, but also to traverse regions where development may naturally be slow. Again, canals must be provided with protected banks to resist the great force of water which is put in motion by the passage of boats or barges through their channels. They are naturally limited in width because of the expense; the cost of a width sufficient for the handling of ocean boats is practically prohibitive, except for comparatively short distances. They may have an advantage in their greater freedom from silt or other obstructions to navigation, but this is ordinarily more than counterbalanced by the difficulty of obtaining an adequate water supply for the main channel or for the locks used in connection with it.

The commission has had under consideration the question of the construction of artificial canals adapted to the passage of seagoing ships. An examination of this subject has led to the conclusion that this class of waterways is only profitable under certain well-defined conditions, of which the following are the best illustrations:

First. Canals connecting navigable waters located near to each other, between which large traffic would naturally exist, except for rapids, a barrier readily overcome, or the existence of a comparatively narrow strip of land. The Sault Ste. Marie Canal, connecting Lakes Superior and Huron, is perhaps the best example. This canal, 1.6 miles in length and constructed at a cost of about $9,300,000, renders the almost unlimited resources tributary to Lake Superior available to the other lakes and provides for a return commerce considerably less in volume. Other illustrations are the Welland Canal, 26¾ miles in length, with 26 locks, connecting Lakes Erie and Ontario, and the Lachine Canal, constructed for the purpose of obviating rapids in the St. Lawrence River.

Second. Comparatively short canals, which save a very great sailing distance, such as the Suez Canal, 87 miles in length, which furnishes a substitute for the voyage around Cape of Good Hope and saves in the sailing distance from Northern and Western Europe to Calcutta 3,700 miles, and to Hongkong, by the Straits of Sunda, 3,300 miles. Also the proposed Panama Canal, 49 miles in length, which obviates a voyage around Cape Horn and saves in the sailing distance from New York to San Francisco more than 8,000 miles. Another illustration is the Kaiser-Wilhelm Canal, 53 miles in length, which, though constructed primarily for military purposes, is largely used for commerce and saves in distance for vessels bound from the English Channel to the Baltic about 200 miles.

Third. Canals from the sea to large cities situated not far from the coast, where communities have grown to large size and become great producers or consumers of freight without connection with the ocean. In these cases, with increased commercial and manufacturing importance, it has become a practical necessity to establish communication with the sea. The best illustration of this class is the Manchester Canal, 35½ miles in length, with a least depth of 28 feet. The canals in Belgium, from the North Sea to Bruges, to Ghent, and to Brussels, are also good examples of this class.

The reasons for the disadvantages of canals as compared with natural waterways are obvious. In a narrow channel a boat moves with much less speed and with far greater difficulty and danger than in a natural waterway where there is sufficient sea room. Since the speed of the slowest boat determines the speed of all, it is not probable that any time could be gained by using a canal unless the distance saved were very considerable. Also, there is the constant danger that in the handling of a large vessel, which is not adapted for navigation in a narrow channel, it will strike against the bank or works of construction and not only incur delay but also serious damage. This possibility increases the cost of insurance. It is conceivable, however, that with improved methods of handling vessels this disadvantage might be somewhat lessened. It should be added in this connection that persons familiar with navigation have stated, in answer to inquiries on this subject, that even if canals of deep draft should be constructed on certain proposed routes in this country and were entirely free from tolls or similar charges, large vessels would make no use of them, preferring to go where there is greater sea room. Ocean-going boats are so expensive in first cost and daily operation that the profits of a whole trip may be consumed by a few days' extra delay. Moreover, the expense per ton of carrying capacity is much greater for an ocean-going boat than for one used in interior waters. The model, also, and the method of handling is different. This difference in cost tends to neutralize any advantage gained in the use of artificial channels by ocean-going boats.

The higher average value per ton of carrying capacity for seagoing vessels over those of inland waters is shown by the following table, compiled from the United States Census Report on Transportation, page 21, which gives the figures for 1906:

	Average value of vessel per ton of carrying capacity.			
	Steam.	Sail.	Unrigged.	All vessels.
Atlantic coast and Gulf of Mexico	$133	$33	$18	$56
Pacific coast (including Alaska)	117	38	30	78
Great Lakes and St. Lawrence River	61	27	32	55
Mississippi River and tributaries	90	....	2	5
All other inland waters	103	32	10	18
Entire United States	95	33	9	39

It thus appears that the average value of vessels per ton of cargo-carrying capacity on the Atlantic coast and Gulf of Mexico is $56, on the Pacific coast $78, while on the Mississippi River and its tributaries it is only $5.

III.

THE NECESSARY STEPS TO BE TAKEN BEFORE THE ADOPTION OF PROJECTS FOR THE IMPROVEMENT OF RIVERS AND HARBORS AND THE METHOD OF MAKING APPROPRIATIONS THEREFOR.

The commission regards the present law, providing for preliminary steps before the adoption of projects for improvement, as well adapted to secure the best results. Under existing statutes it is required that when the improvement of a river or harbor is advocated, before any plan is adopted there should be legislation by Congress in the form of a concurrent resolution or other measure which shall direct that an investigation of the improvement be made. This investigation contemplates two successive steps—first, a preliminary examination; second, a detailed survey—both of which are made by the Engineer Corps of the United States Army, and are reviewed by an organization known as a "Board of Review," created by the River and Harbor Act of 1902, with the object of securing uniformity in recommendations before projects are adopted, and with the thought of bringing to bear upon the proposed improvements under investigation a more elaborate and careful consideration. If on the first or preliminary examination the report is unfavorable, no further action is taken without the further order of Congress. The law on this subject is contained in the River and Harbor Act of March 3, 1909. It is as follows:

> In all cases a preliminary examination of the river, harbor, or other proposed improvement mentioned shall first be made, and a report as to the advisability of its improvement shall be submitted, unless a survey or estimate is herein expressly directed. If upon such preliminary examination the proposed improvement is not deemed advisable, no further action shall be taken thereon without the further direction of Congress; but in case the report shall be favorable to such proposed improvement, or that a survey and estimate should be made to determine the advisability of improvement, the Secretary of War is hereby authorized, in his discretion, to cause surveys to be made, and the cost and advisability to be reported to Congress. Such examinations and surveys shall be reviewed by the Board of Engineers for Rivers and Harbors, as provided in section three of the River and Harbor Act of March second, nineteen hundred and seven: *Provided*, That every report submitted to Congress in pursuance of this section, in addition to full information regarding the present and prospective commercial importance of the project covered by the report, and the benefit to commerce likely to result from any proposed plan of improvement, shall contain also such data as it may be practicable to secure regarding (first) the establishment of terminal and transfer facilities, (second) the development and utilization of water power for industrial and commercial purposes, and (third) such other subjects as may be properly connected with such project: *Provided further*, That in the investigation and study of these questions consideration shall be given only to their bearing upon the improvement of navigation and to the possibility and desirability of their being coordinated in a logical and proper manner with improvements for navigation to lessen the cost of such improvements and to compensate the Government for expenditures made in the interest of navigation: *And provided further*, That the investigation and study of these questions as provided herein may, upon review by the Board of Engineers for Rivers and Harbors when called for as now provided by law, be extended to any work of improvement now under way and to any locality the examination and survey of which has heretofore been, or may hereafter be, authorized by Congress.

Under the foregoing plan if the final report is favorable, it is considered that a basis exists for the making of an appropriation for the proposed improvements. The recommendations of the engineer officers are not necessarily final, though since the passage of the law the rule has been adhered to as a fixed policy that no project should be undertaken by the Government or appropriated for which does not have the recommendations of the board of review and the Chief of Engineers. At the time of the creation of the board, in 1902, projects of an aggregate cost of $400,000,000 or more, recommended as worthy of improvement, either had not been commenced or were in a partly finished condition, and necessarily the work of Congress was one of selection, under which the most pressing projects alone were sure of attention.

The commission would advise that without a careful and unbiased examination of proposed improvements of the nature now required by statute no project should be adopted by Congress. Numerous propositions have been made for the creation of a board of public works, or other body, which shall decide upon the feasibility and desirability of propositions for expenditures on rivers and harbors. The commission is unwilling to recommend a change of this kind, and points to the fact that the past recommendations of the Engineer Corps have been carefully prepared and with a degree of expert knowledge and comprehension of the commercial needs of the country which could not well be supplied by any other body or organization. The advantages which attach to the Engineer Corps are obvious. The members are in the permanent service of the Government, and are free from those influences which would inevitably be brought to bear upon men in civil life. Those engineers now engaged in the work are carefully trained in the planning and execution of these improvements, and have special qualifications for judging the feasibility and the cost of proposed river and harbor projects. They also have a good general knowledge of the probable commercial results which would accrue, though on this point their opinions have not been regarded as conclusive. In this connection the commission would call attention to the necessity for an increase in the membership of the Engineer Corps.

The commission would recommend that hereafter the general policy be adopted of providing for the early completion of any and all projects which are undertaken, and that only such number of projects should be commenced as will be appropriated for and completed within a reasonable time. In this way definite results can be relied upon, plans can be made for the utilization of the streams improved, and, in addition, a very large saving in expense may be secured. If this is done, projects will be more carefully considered before they are adopted. Careful provision should also be made for the maintenance of existing works, otherwise the improvements already made will deteriorate. In the general policy of improving streams in waterway systems, it is advised that the main stream be improved first and raised to an adequate stage of efficiency at an earlier date than the tributary streams; that in the improvement of any particular river, preference should be given to the lower portion, and that the improvement should proceed from the mouth up, unless the regimen of the river makes a different rule desirable, or an independent stretch of the river exists remote from the mouth upon which salutary results can be more readily obtained.

There are manifest benefits in securing standardization or equal depths in all channels, so that boats of the same size may be utilized everywhere. This would prevent the very considerable expense of loading and unloading whenever there is a transfer between channels of different draft or capacity. If a uniform depth can be secured, especially in locks and improvements of artificial construction, it should be accomplished. The fact, however, must not be overlooked that the very great difference in the size of the streams which make up any river system renders complete standardization difficult and exceedingly expensive, if not impossible.

The continuing contract system was first tried in the year 1890. Under this plan the whole or any part of an estimated expenditure is, whenever desirable, authorized at one time, and the amounts needed as the work progresses are provided from year to year by appropriations carried in the sundry civil act. This system, to some extent and with beneficial results, has been used in each subsequent river and harbor act, except in 1894, and its continued use is recommended. In the case of small streams or harbors, however, it is not essential. Nor is the authorization of a contract for completion desirable, as a rule, in the case of very large projects, where the amount necessary for completion is indefinite or a very long time is required. In many instances the work extends over a long period, because the necessary plant or equipment must be collected gradually, and the work, if hastened too rapidly, becomes unnecessarily expensive. In these cases, as well as in others, a large discretion as to time of completion is necessarily left to the executive department, which can carefully consider all phases of the situation and secure such prosecution of the work as will be most beneficial to all concerned.

IV.

THE PROPER DIVISION BETWEEN APPROPRIATIONS BY THE FEDERAL GOVERNMENT, ON THE ONE HAND, AND BY THE STATES, MINOR POLITICAL DIVISIONS, AND INDIVIDUALS, ON THE OTHER HAND.

Numerous propositions have been made for a change of policy by Congress, so that the expense of river and harbor improvements shall be divided between the Federal Government and States, cities or communities, and individuals. Widely different policies have been adopted by various countries in the making of river and harbor improvements. It is difficult to draw any exact line in the classification of these policies, but, roughly speaking, it may be said that there are three methods employed.

1. That under which these improvements are left to individual or local enterprise, with the right to impose tolls upon the boats which utilize them. This policy is best illustrated in Great Britain, where the improvement of inland waterways, such as canals and rivers, is, with few exceptions, prosecuted by private corporations or navigation companies. Harbors in this country are improved either by municipalities, as at Bristol and at Southampton, in the first instance, or by railway companies which desire seacoast terminals, or by dock and harbor boards affiliated with the city government, as at Liverpool. In all these cases the construction of docks, the dredging of channels, and the building of breakwaters are taken care of by the same company or agency. In practically all cases tolls are charged.

2. That under which the General Government prosecutes improvements and levies tolls. This is well illustrated by certain harbor improvements in France, where, in addition to the dredging of the channels, the Government provides docks and harbor facilities.

3. That in vogue in the United States, under which the General Government improves rivers either by open-channel work or by the construction of locks and dams, and charges no toll therefor, rendering navigation entirely free. Under this method in the United States there is likewise an improvement of harbors by the dredging of channels or anchorage spaces. Provision is also made for protection against the sea by breakwaters or otherwise. These improvements are not made the basis of a charge, though port dues are imposed, as in most, if not all, countries without regard to improvements made. This method, so far as it relates to canals and canalized rivers, was also adopted in France in the year 1879, and is still in vogue in that country, except as regards a considerable number of new works provided for in 1903 or later, under which there is participation in the expense, the General Government, as a rule, bearing 50 per cent of the cost, and localities immediately interested the balance. In this case the localities which contribute money for the improvement are authorized to collect tolls for their reimbursement.

In our own country, until the time of the civil war, no considerable amount was expended for the improvement of rivers and harbors. For the most part our rivers were neglected, and in many cases, as in Ohio, Illinois, and New York, canals were constructed at the expense of the State, though oftentimes with the aid of a grant of land from the Federal Government. Many canals were constructed by private companies. This class of improvements was regarded by one school of public men as outside the scope of the Federal Government, and for decades was vigorously opposed in many parts of the country. The constitution of the Confederate States of America, framed at Montgomery in February, 1861, in the enumeration of the powers of the General Government, contained the following provision, which may be said to express one interpretation of the Federal Constitution on this point, as well as one view of the best policy to be adopted:

> To regulate commerce with foreign nations, and among the several States, and with the Indian tribes; but neither this, nor any other clause contained in the constitution, shall ever be construed to delegate the power to congress to appropriate money for any internal improvement intended to facilitate commerce except for the purpose of furnishing lights, beacons, and buoys and other aids to navigation upon the coasts, and the improvement of harbors and the removing of obstructions in river navigation, in all which cases such duties shall be laid on the navigation facilitated thereby, as may be necessary to pay the costs and expenses thereof.

In recent years there has been a noticeable lack of uniformity in the method of providing funds for these improvements. The State of New York in the year 1903, by popular vote, adopted a constitutional amendment providing $101,000,000 for a barge canal. In the year 1908 the people of Illinois, by the same method, voted an amendment to the constitution which allows the issue of bonds by the State to an amount of $20,000,000 for part of the expense of a deep waterway from the Lakes to the Gulf. In the original authority for the Chicago drainage canal, provision was made that it might be a link in, or part of, a navigable waterway from the Lakes to the Mississippi River. At a very recent date provision has been made for a private canal in the State of Massachusetts, with a view to shortening the sailing distance and avoiding the dangerous passage in the open sea around Cape Cod. This enterprise contemplates the expenditure of private capital for the construction of the canal, also the charging of tolls. In numerous instances in other States, as in Oregon, Washington, Ohio, Pennsylvania, and California, provision has been made for waterway improvements, either independently or in cooperation with the General Government. Some municipalities have also voted large sums for harbor improvements. At the last session the legislature of Texas passed a law (see General Laws of Texas, 31st Legislature, pp. 32 to 45) authorizing the formation of navigation districts, which districts may issue bonds, levy taxes, and condemn property in the prosecution of river and harbor works. At the last general election, in1909, the people of Rhode Island authorized the expenditure of $500,000 for the improvement of Providence Harbor.

The commission finds that, in the development of waterways on a large scale, the decided tendency in other countries is toward a degree of participation by communities and localities especially benefited and is of the opinion that in order to obtain the best results this policy must ultimately be adopted in our own country. In the meantime, it is desirable to encourage participation by communities whenever their proposed improvements are worthy of recognition by the Federal Government. The objections to this plan of participation are that the necessity of including different localities and States in a single improvement would require a concert of action by numerous and perhaps varying interests, often impossible to obtain. This applies especially in the case of rivers passing through or by several States. Another objection is that less-deserving projects, presented with offers to furnish a portion of the cost, might obtain recognition to the exclusion of more useful projects for which less pecuniary support could be furnished. On the other hand, it can not be denied that in most instances river and harbor improvements confer an especial benefit upon portions of the country most nearly affected; that there is a constant danger of insistent pressure upon the Federal Government for the expenditure of money upon projects which have not been maturely considered, and which, if part of the burden were chargeable to the localities in which they are advocated, might not be presented to Congress. Again, in the accomplishment of any large and comprehensive plan for the full development of inland navigation throughout the country, and of the associated uses of water, the cooperation of all communities and interests is especially desirable. There is the further fact that terminal facilities are an integral part of any well-devised plan for waterway improvement. These, at least, should be provided by the communities immediately benefited. It has been brought to the attention of the commission that in some instances heavy burdens have been laid upon traffic by exorbitant charges for the privilege of mooring at wharves owned by municipalities or private individuals. There is a palpable unfairness in these cases, because the Federal Government is expected, without burden on the communities interested, to expend its money for river and harbor improvements, while the communities themselves show no disposition to cooperate, and, in a measure, nullify the benefits secured by the large federal expenditures.

In passing from this subject the commission would recommend:

1. That in the improvement of rivers and harbors similarly situated, where equitable division is possible, uniform rules be observed for a proper division of cost between the Federal Government and minor political divisions. There is at present a lack of uniformity. One illustration of this is in the improvement of interior channels and harbors. In some cases the expense is borne exclusively by the Federal Government and in other cases by the municipalities interested.

2. That participation in improvements by local communities be encouraged, always with due care to avoiding the adoption of projects which are unworthy of recognition by the Federal Government.

3. That improvements not essential to navigation should not be undertaken by the Federal Government.

4. That improvements in rivers and harbors be not made unless sufficient assurance is given that proper wharves, terminals, and other necessary adjuncts to navigation shall be furnished by municipal or private enterprise, and that the charges for their use shall be reasonable.

V.

THE RELATION OF WATERWAY IMPROVEMENTS TO BANK PROTECTION, FLOOD AND DROUGHT PREVENTION, IRRIGATION, AND DRAINAGE.

In providing for the future development of the country, consideration must be given to the fact that water, as well as land, is an asset which makes up an integral part of our natural wealth. Waters must ultimately be utilized not merely for navigation, but also for irrigation and for power, when available for these purposes; also, all practicable means must be used for their clarification and for the prevention of floods and droughts.

It is desirable that whenever navigation is improved the most careful attention be given to these other associated objects, and while it is not the opinion of the commission that waterway improvements for the development of navigation should be deferred until a comprehensive and final plan for the utilization of waters can be devised, on the other hand subjects pertaining to the control and most beneficial utilization of water should at all times be considered, and improvements looking to the promotion of navigation should, as far as possible, harmonize with the general uses and beneficial control of waters. The subject of water power receives separate attention under heading VII of this report. Irrigation projects are now provided for by separate legislation under an act of Congress passed in 1902. All reasonable means for the prevention of floods should be utilized. Water when uncontrolled becomes a most destructive agency. One of the most injurious of its effects is in the erosion of banks, which varies greatly with the periodical changes in river level and which is usually greatest during high floods or during their subsidence. It should always be borne in mind that the waterway improvements made by the Federal Government under the exercise of its authority should be restricted to navigation. Whenever bank protection or flood prevention or the clarification of water is the sole object of improvements, the question presents little difficulty in its solution. Such projects are not a proper charge upon the Federal Treasury. A more difficult problem, however, is presented where the improvements just mentioned have as their object both navigation and the protection of private property. In such cases, in the opinion of the commission, the expense should be apportioned between the Federal Government and communities directly interested. In many instances proposed improvements have as their main object the protection or benefit of private property. In such cases there is a distinct benefit conferred upon individuals or localities which is only of a remote or very indirect benefit to the country as a whole. Lands subject to periodical overflow or lands of uncertain value because of the danger of erosion, when improved, are multiplied many times in value, and there is a constant danger that such improvements will be advocated under the guise of river and harbor legislation framed to benefit navigation, when the real object is the benefit which will accrue to individuals or localities.

Beginning in 1902, river and harbor acts have provided that the protection of banks should not be appropriated for out of the National Treasury unless the improvement is required in the interest of navigation. The levees upon the lower Mississippi are an apparent exception to this rule, but when the construction of these levees was first undertaken by the Federal Government they were regarded as necessary for navigation and as an essential feature in securing a proper regimen for the Mississippi River. The question whether they are an aid to navigation is one which has been much discussed, some stating that they promote navigation and others that they do not, the prevailing opinion being that they have a direct effect upon the maintenance of the channel and an indirect effect upon navigation. In any event, more than half of the cost of these levees constructed since the time when the Federal Government commenced to have part in their construction has been borne by the States or communities bordering upon the river. Drainage projects can be advantageously prosecuted in conjunction with navigation improvements. The prevention of overflow during floods is helpful to navigation, though not essential to its existence. The line should, however, be carefully drawn between improvements which, in whole or in part, are for the protection or development of private property and those which are made in the sole interest of navigation.

Measures must ultimately be taken to permit and facilitate the greatest possible protection of property abutting on navigable and nonnavigable streams. It is desirable for the proper conservation and utilization of the resources of the country that these valuable lands should be protected. The commission would, however, repeat in this connection the recommendation made in No. IV, that improvements by the Federal Government be restricted to those essential to navigation, and would also recommend that, whenever a project is under consideration or is in operation under which a very considerable amount of land will be reclaimed or protected from overflow, a survey be made and report be submitted as to the cost of the reclamation features of such project and as to the probable quantity and value of the land which would be reclaimed or benefited thereby.

VI.

POLICY RELATING TO HARBORS, INCLUDING THE OWNERSHIP AND CONTROL OF WHARVES AND DOCKS.

The question of the improvement of harbors, as a general proposition, presents little difficulty. The liberal policy heretofore pursued by the Government in this regard has greatly benefited the public and has resulted in a great increase in wealth to the country at large. The harbors so far improved have furnished outlets for our exports and made the products of immense areas in the interior readily available for shipment abroad or for use at home. They have been useful both to the foreign and coastwise trade, and made possible the entrance of boats of the deepest draft, thus greatly diminishing the rates of freight on ocean shipments. In addition, the construction of breakwaters and other means for the protection of the available space within numerous ports of the United States has served a most beneficent purpose in the more adequate protection of human life. These ports have as feeders not only the river systems and canals of the country, but also its great network of railways. It must be conceded that in comparing the benefits conferred by harbor improvements with those of river improvements, the former have been more uniformly helpful, though in some instances the appropriations for river and lake channels have brought an equal or even greater return than usually results from expenditures upon harbors.

The commission recommends the continuance of the progressive policy which has been adopted relating to harbors, but would advise a division of harbors into classes by depth or by the importance of their ocean or coastwise traffic. The greatest channel depth, which now is 30 to 40 feet, is not required save in great entrepôts of commerce, in the development of which it is probable that even greater depths than those now required may in time become necessary. Uniform and reliable channels, which can be depended upon for a certain depth and width from year to year and at all times, are the first essential.

The commission recommends care in avoiding an undue multiplication of ports; that is, it is undesirable to have three or four minor harbors insufficiently developed in a locality where one well-improved port will serve the purpose. Under the stress of local demands harbors have in some instances been improved where the money could have been more economically expended in the better development of those already in existence.

In recommending the improvement of harbors on a liberal scale the commission calls attention to the necessity for rendering them useful to the largest possible number, and thereby preventing a monopoly of benefits by a few corporations or individuals. Instances are not lacking in which the land suitable for terminals adjacent to improved harbors is owned by one corporation or by a comparatively small number of individuals. If improvements should be considered desirable where the number of water-front owners is small it is advised that a condition be carefully imposed to the effect that wharfage facilities shall be made available to the public generally, and that the charges for the same shall be submitted to the Secretary of War or other official for his approval.

It is also recommended that a proper dividing line be drawn between the work to be done under appropriations by the Federal Government and that by cities and individual owners. Provision for a safe entrance into a bay or harbor sufficient to afford safety to shipping and suitable anchorage grounds in proximity to cities thereon is the full duty of the Federal Government. Minor channels leading to wharves in harbors as well as upon rivers should be provided by communities or individuals.

The construction of wharves and docks by the Government has been advocated; but the commission is unwilling to recommend such a policy. In the first place, the total expense of harbor improvements would be greatly increased, and under such a policy money which might be expended for general purposes would be used for work that should more properly be left to municipalities or private parties. In deciding whether a harbor improvement is to be adopted or not, it is wise to omit those cases where there is not assurance that local or private enterprise will furnish all needed terminal facilities.

VII.

RELATION OF WATERWAY IMPROVEMENTS TO WATER POWER.

The commission has had under consideration the use of water power in connection with the development of navigation, as well as plans for the utilization of power and the right of the Federal Government to control or use the same.

The subject of water power is not within the scope of the inquiries of the commission, except as it is associated with navigation. The members, however, have given much attention to this general subject and strongly recommend the greatest care in the conservation of water power for the use of the people. Its value has not been fully understood, and power derived from navigable and nonnavigable streams will undoubtedly be developed to a much greater extent in the future and for a larger variety of uses. The commission especially recommends such legislation by Congress and by the States as would prevent monopoly in the possession of water power, and secure, to the greatest possible degree, its utilization for the general benefit.

The rights of the Federal Government in water power may be viewed from three different standpoints:

First. Cases in which power is developed on streams located in public lands, where undoubtedly the Government, so far as the rights pertaining to abutting ownership are involved, has full control, and should exercise the greatest care in granting away whatever rights it may have.

Second. When power is developed in nonnavigable streams, where there is private or state ownership, in which case no federal authority to regulate or control exists, except to prevent interference with the navigation of other streams.

Third. When water power is developed in navigable streams. In this case several plans have been proposed for the collection of tolls upon the water power developed by dams whenever their construction is permitted by Congress. The right of the Federal Government to collect such tolls must rest on one of three theories:

1. That the Federal Government has some proprietary right in the waters of navigable streams, so that the collection of tolls can be based upon actual ownership of, or right in, the waters.

2. That, as the right to grant or withhold consent for the construction of a dam in navigable waters rests in Congress, it is allowable to make a charge for the consent or privilege and authorize the collection of tolls.

3. That the Federal Government in its jurisdiction of interstate commerce has control of navigable streams and has a certain degree of responsibility for their improvement. Under this theory it is maintained that tolls upon the water power developed can be collected and paid into a fund for the improvement of navigable streams, including not only the one on which the toll is charged, but all others capable of improvement for navigation.

The commission is of the opinion that the Federal Government has no proprietary right or interest in navigable waters which would authorize the collection of tolls. The right, if it exists at all, rests upon either the second or third theory stated. As regards the second theory, it should be said that the imposition of tolls, unless based upon a more substantial foundation than the mere authority to grant or withhold consent—an authority arising solely from the control of the Federal Government for the purposes of navigation—does not commend itself to the commission, and it is to be doubted whether, even in case a bill should be passed or other action taken by Congress for granting this permission, with a provision for charging tolls, such tolls could be collected. Regarding the third theory stated, it should be noted that under the exercise of the taxing power Congress can levy taxes for general revenue purposes upon all classes of water power, whether in navigable or nonnavigable streams, and if charges are to be imposed it would seem that this is the normal method. It should further be borne in mind that a requirement for the imposition of tolls where the right to construct dams is hereafter granted would cause a discrimination between water power to be utilized under future permits and those already enjoyed, which are subject to no such charge. It must of course be remembered that whenever the privilege of constructing dams is granted in a navigable stream there is an undoubted right to impose charges sufficient to pay the expenses of examination and supervision and to secure the Government against cost by reason of obstacles to navigation created by the erection of dams; but this rests upon an entirely different principle from the proposal to charge tolls.

The control of the Federal Government over navigable streams has to do with navigation only, and in the exercise of this jurisdiction the plan commends itself to the commission of inserting in each grant or franchise under which the consent to construct a dam is given a condition that the grantee who constructs the dam must also, whenever necessary to subserve the interests of navigation, construct a lock suited to the locality and to the probable development of traffic, and also furnish power for the proper operation of the lock or locks. These requirements, rather than the imposition of tolls, appeal to the commission because they are free from legal objections and are in entire accordance with the objects for which the Federal Government has jurisdiction over navigable streams.

Whenever the Government constructs dams for purposes of navigation or irrigation, and, as an incident thereto, water power is developed, such power should be utilized and an adequate charge made therefor.

The commission would call attention also to another important step in the control of water power, namely, that before the right to construct dams in any navigable stream is granted there should be a careful survey of the whole stream, or at least of that portion the regimen of which will be affected by the proposed construction. In the development of water power there is danger that dams will be located or constructed in such a manner as not to accord with the most helpful development of navigation.

The commission accordingly recommends that whenever permission to construct a dam in a navigable stream is requested consent shall not be granted until a survey has first been made and the proper location of dams has been determined.

It may also be stated that it is the opinion of the commission that if constitutional authority therefor exists a provision should be inserted in these grants giving to the Secretary of War or other official the right to regulate charges for power furnished to consumers.

A provision reserving to Congress the right to alter, amend, or repeal should be inserted in every act granting water-power rights.

VIII.

METHODS IN THE IMPROVEMENT OF RIVERS, INCLUDING THE CONSTRUCTION OF LOCKS AND DAMS.

The general course of river improvement for purposes of navigation in both Europe and America is, briefly, as follows:

1. A river survey.
2. The removal of trees, snags, and other accidental obstructions.
3. The straightening, deepening, buoying, and lighting of the natural channels.
4. The revetment of banks to stop their erosion and the construction of levees to prevent outflow over the banks.
5. The regularization of the open river, or the standardizing of its bends, its cross sections, and its water slopes, obtained by longitudinal dikes which direct the water flow and form new banks, by spur dikes which determine the channel and regulate the waterflow, and by occasional submerged cross dikes which protect the bed of the river from excessive erosion, and maintain general river slopes.
6. The canalization of the river, obtained by the use of dams converting the river into a series of deep-water pools, and by the use of locks or other means of raising or lowering boats from each pool to the adjacent one.

The last two steps are often alternative propositions.

Such a plan of improvement is being followed on nearly all the navigable rivers of England, France, Belgium, and Germany, about half of which have already been carried through the entire programme.

In all the above stages of improvement the United States has little to learn from Europe in methods.

The Mississippi River from St. Paul to the mouth of the Missouri is a good example of a river which, from its moderate slope, good low-water discharge, and moderate high-water discharge, is capable of an excellent natural open-river navigation for light-draft boats; which can easily be regularized for medium-draft boats; or which can be canalized for boats of any draft. From the mouth of the Missouri

River to the Gulf, the Mississippi, with its large low-water and large high-water discharge and mobile bottom, can be regularized, though engineering difficulties render the cost per mile greater than any other river work in the Mississippi Valley system. But it can not easily be canalized. The Ohio River, on the other hand, on account of its small low-water discharge can not easily be regularized for even light-draft boats, although it can be canalized for medium drafts.

Regularization of a river to give a good open-river navigation is only practicable on rivers with a gentle slope of river bed and a large low-water flow compared with a freshet flow, such as the Mississippi River below St. Paul, the Missouri River below the Yellowstone, the lower portion of many of their tributaries, the Hudson, the lower portion of the Atlantic and Gulf rivers in America, and in Europe the Rhone, Garonne, Durance, Loire, Lower Meuse, Rhine, Weser, Elbe, Lower Oder, Vistula, Nemel, Danube, Dneiper, Volga, and the tidal portions of other rivers. But even in these cases, on the lower and most favored parts of the Rhine above the Dutch frontier, and the middle parts of the Danube, the low-water flow has neither justified nor secured a low-water channel depth of over 3 meters (9.8 feet), nor of over 2 meters (6.6 feet) on the other European rivers, and on some of these rivers only as much as 1 meter (3.3 feet). A greater depth will probably require canalization. However, these depths, combined with the free, open river circulation, a perfected boat service, and fine terminal facilities, have on the German rivers led to an enormous tonnage of water traffic. North American rivers, as a general rule, surpass European rivers in length, in depth, and in water flow. The Rhine and the Danube are the only rivers of Europe, outside of Russia, with a greater low-water flow than the upper Mississippi River above the mouth of the Missouri.

Whenever the river slope is too steep and the corresponding current too great to be easily ascended by ordinary tows, and an open-river navigation is still preferable to canalization, the boat service is sometimes maintained by the aid of special chains or cables, laid under water along the bottom of the river, by which the boats pull themselves upstream. The use in Europe, however, of cables or chains is diminishing rather than increasing. In the United States there are but few places where this system would be useful.

Where the river slope is steep or the low-water discharge is small or where a draft greater than practicable by open-river methods is desired, the river improvement is usually best obtained by canalization.

The movable type of dam is the one most common in river canalization work, its great advantage being that it lies flat on the river bottom during high waters and opens the entire river to free navigation as long as the high water continues.

The earliest and most persistent type of lock and that still most generally used everywhere is the ordinary masonry lock, composed of two masonry side walls, closed at each end by movable doors or gates, the resulting inclosure or chamber being furnished with valves and passages by which it can be filled with water from the upper pool and can discharge its water into the lower pool.

When the boat traffic is very great and the highest pool of a river receives but little water from its tributaries, the lack of proper water supply may limit the river traffic and require either a change of lock construction to some other type using less water or else a pumping plant. A desire to economize water, combined with a desire to hasten the passage of boats through locks, is the main reason for the substitution during recent years of inclined railways or "canal inclines" and vertical lifts for the masonry lock. But the tendency of to-day in Europe seems to be toward retaining the masonry lock type, unless the conditions of dam location and of boat traffic are exceptional. In this connection, attention is invited to the fact that a high masonry lock is being built alongside of the Henrichenburg pneumatic lift on the Dortmund-Ems Canal, in Germany, and the hydraulic apparatus of the Anderton lift on the Weaver River canals near Liverpool, England, has recently been replaced by mechanical counterpoises and electro-dynamic machinery. There seems to be no good reason, therefore, for changing the existing practice in the United States, which is slow to give up the use of masonry locks.

Where a considerable height is to be overcome by masonry locks, there is usually a choice between the use of several locks of small lift and a lesser number with larger lifts. The present tendency is toward larger lifts.

In the matter of construction details, the European locks seen by the commission, while interesting as parts of the river improvement system, contained but few features not already in use in the United States.

There are many reasons why open river navigation is preferable to a lock and dam or canalized navigation; among others, the capacity for practically unlimited traffic, easier travel during freshets, and very much greater speed of boat travel, especially downstream. One great recommendation of open river navigation is its relative economy. Canalization is almost always very expensive, both in first cost and in subsequent operation, so that its adoption must assume a reasonable certainty of great water traffic over the improved route.

While the growth of traffic may eventually demand with propriety either the thorough regularization or canalization of all navigable waterways, there are always in every country, and especially in the United States, many streams whose water slopes, water flow, character of banks and bed, etc., will render thorough improvement by either method above described too expensive to be justifiable from an economic standpoint.

IX.

COMPARISON OF EUROPEAN WATERWAYS WITH THOSE OF THE UNITED STATES, INCLUDING AN INVESTIGATION OF EUROPEAN AND AMERICAN TRANSPORTATION RATES BOTH BY LAND AND BY WATER.

A majority of the commission made an inspection of European waterways in the months of August, September, and October, 1909, visiting especially England, France, Germany, Holland, Belgium, Austria, and Hungary. Typical harbors, as well as most of the important rivers and canals of these countries, were examined, and numerous conferences were held with the engineers and other officials having them in charge. In practically all these countries waterways have attained a high standard of development. This is due both to the fostering care of the states or political subdivisions and to private enterprise. In Germany, especially, and in fact in all countries except England, the increase of inland water-borne traffic has been marked, as shown by the following table, compiled from Volumes VI and VII of the Reports of the British Royal Commission on Canals and Waterways, recently published.

Tonnage of European waterways.

[In 1,000 metric tons.[a]]

Country.	1875.	1880.	1888.	1905.	Percentage of increase.	Average annual increase.
England and Wales[b]			33,124	32,340	−2.4	−0.14
France		18,000		34,030	89.0	3.6
Germany[c]	20,800			103,400	397.0	13.2
Belgium		24,836		53,345	114.0	4.5

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[a] The total tonnage for these countries is calculated by adding together total receipts and shipments, but since this method is uniformly employed the percentages of increase are reliable.
[b] Excluding sea-borne traffic on the Manchester Ship Canal.
[c] The tonnage of some minor streams is only estimated.

The great increase in water-borne traffic in Germany shown in the table above is mainly upon her important rivers. In 1875 the seven main rivers carried 60 per cent of the total traffic and in 1905, 80 per cent. On the Rhine alone between Kehl and the Dutch frontier 43 per cent of the total traffic was carried, and on the Elbe between Hamburg and the Austrian frontier 24 per cent was carried. The total length of free and canalized rivers and of canals in several European countries is shown by the following table, compiled from Volume VI of the Report of the Royal Commission on Canals and Waterways:

Classification of waterways.

[Length in miles.]

	Principal lines.			All waterways.
	Free rivers.	Canalized rivers.	Canals.	
England and Wales	812.0	1,312.0	1,927.0	4,053
France	[a]796.0	970.1	1,776.7	7,485
Germany	1,948.0	425.2	894.8	6,200
Belgium	74.5	307.0	334.2	1,015

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[a] The Loire for 166 miles between Briare and Nantes is paralleled by a canal and is only used by small boats.

According to Part I of the Report of the Commissioner of Corporations on Transportation by Water in the United States (see pp. 28, 29), there are 295 navigable streams in this country having a navigable length of approximately 26,410 miles. Forty streams, with a length of 2,600 miles, have a 10-foot navigation, and 70 more, with an additional length of 3,200 miles, have a depth of from 6 to 10 feet, during the greater part of the year. The Mississippi River and its principal tributaries alone have about 2,500 miles of 6-foot low-water navigation. There are at present in the United States 45 canals still in operation, with a length of 2,189.04 miles. Of these, 17 government canals aggregate 194.49 miles in length, 12 state canals aggregate 1,358.98 miles, and 16 private canals aggregate 635.58 miles. Hence the total length of all navigable rivers and canals in operation is about 28,600 miles.

Upon the Rhine, the most important inland waterway of Europe, the traffic has assumed enormous proportions, showing an increase greater than on any waterway of this country, except possibly the Great Lakes. In 1875 the average tonnage per mile upon this river for the 351 miles above the frontier of Holland was 1,560; by 1905 it had mounted to 11,400, an increase of 631 per cent. On the canalized portion of the river Main, one of the smaller tributaries of the Rhine, the traffic has increased from 296,000 total tonnage in 1887 to 2,552,000 in 1905. This enormous increase has taken place in spite of the fact that the Rhine at no place above the Dutch frontier is more than 10 feet deep at ordinary low water, and the depth of the Main is even less. The low-water depth of the Rhine is only 9.8 feet for 110 miles from the Dutch frontier up to Cologne; thence 8.2 feet for 82 miles to St. Goar; thence 6.6 feet for 79 miles to Mannheim; and thence 4 feet for 84 miles to Strassburg. The Main has a low-water depth of 7.5 feet from the Rhine for a distance of 26.5 miles to Offenbach; and only 2.6 feet for the next 217 miles to Bischberg.

The canals of all the European countries visited by the commission, except those of England, have shown in the aggregate a steady increase in traffic, although there are instances of abandonment or marked diminution. This increase has taken place on canals which, with few exceptions, are of shallow draft, the average depth being about 6 feet. In France the average annual increase has been about 3 per cent. This is in marked contrast to the record of canals of this country, which, except for a comparatively few ship canals connecting the Great Lakes, show a decrease of 73 per cent from 1880 to 1906. This decrease is partially explained by the fact that, since 1880, about 888 miles of canals have been abandoned.

The general policy of almost all European countries has been toward the development and improvement of their waterways, though of late years in a few instances projects already adopted have been abandoned or prosecuted without assurance of early completion. It is difficult to make reliable comparisons between the amounts expended for waterways in those European countries in which the General Government appropriates money for this purpose, and the amounts spent in the United States, partly because in Europe the expense of improvement is often shared by the state and the provinces, districts, and individuals affected, and partly because far greater amounts have been expended for wharves, ice harbors, local basins, and other facilities for harbors and river-borne commerce than is customary with us. Inland harbors especially are developed on a much more extensive scale in Germany, France, and Belgium than in the United States. The city of Frankfort, for example, is now carrying out new harbor works, the cost of which, including land purchase, will be approximately $17,640,000. The whole amount will be defrayed by the city without state aid.

From 1814 to 1900 the Government of France spent on inland waterways approximately $301,000,000 for improvement and construction (including levees, revetments, etc.), and over $148,000,000 for maintenance and heavier repairs. Belgium spent for the construction of state waterways from 1831 to 1905 about $77,000,000, and for current improvements and maintenance about $24,000,000. Between 1813 and 1906 Prussia spent for waterway construction and improvements about $129,000,000, and for maintenance in 1905 about $4,000,000. The congressional appropriations in the United States for the survey, improvement, and maintenance of harbors and waterways from 1802 to March 2, 1907, amounted to almost $553,000,000, of which sum about $69,000,000 were spent up to 1906 upon canals and canalized rivers. In an official document published in 1903 the relative amounts appropriated for rivers, harbors, and canals to and including December 31, 1902, is stated, namely, $221,869,759 for rivers, $147,448,903.32 for harbors, and $33,237,857.24 for canals. But it must be remembered that the United States is about eighteen times as large in area as either France or Germany, and the length of its navigable rivers and canals is nearly four times as great as in France and more than four times as great as that of Germany. In all these cases what the central governments have appropriated for waterway improvements is only a part of the total amount expended. In the United States, for instance, about $214,000,000 have been spent upon canals by States and corporations.[a]

The increase of traffic on the waterways of Europe in contrast with the decline on many streams of the United States is due, in part at least, to the very great difference between conditions in Europe and those in the United States, of which the following are, it is believed, the most important:

1. *Difference in density of population.*—The United States is much less densely populated than Europe. In 1909 the population was estimated at 46 inhabitants per square mile for the entire United States, while for entire Europe it was approximately 107. In Germany the population is 290 per square mile, and in Belgium it is 620. The greater density of population in Europe tends to increase the quantity of freight in a given area, though this statement must be made with some limitations, due to the lower average of consumption and the less degree of industrial activity in some parts of Europe. At the same time it is a notable fact that the railway mileage per square mile in the United States, at least in the settled portions, is equal to or greater than that in Europe, while the entire mileage per thousand of population is five times as great, thereby showing that the United States is much more adequately furnished with means for railway transportation.

2. *The earlier development and greater relative advantages of waterway systems in Europe.*—In Europe the waterways were developed and in very general use before the introduction of railways. Factories, as well as warehouses, were located with reference to such waterways, and great reliance was placed upon waterway transportation as a means of industrial growth. The European waterways were constructed in many cases at a time when the question at issue was only between transportation by wagons and by boats; and consequently the European railway systems constructed at a later date were not developed to the same degree of efficiency as those in America. It is also more difficult to provide railways in Europe because of the very high cost of rights of way; and in this connection the opportunity for better-

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[a] Census Report, Transportation by Water in 1906, p. 44.

ments in the way of eliminating grades and curves is much less in Europe than in America. The carrying capacity of the European freight car is but a fraction of that in the United States.

3. *Trade movement.*—Another difference as compared with the United States is the greater fixedness in Europe in the location of manufacturing cities, as well as in the lines of distribution of raw material due to the earlier development of coal mines and other sources of material. The shifting of the centers of production which arises from the development of new coal mines and new centers of manufacturing, as well as from the great growth of population, is much less common in Europe than in the United States. This makes it possible to utilize an established waterway with a greater assurance of profit and with greater dependence upon it as a means of transportation.

4. *Habits and customs.*—One social condition, entitled to very considerable weight, is the existence in Europe of a class of boatmen who, for generation after generation, apply themselves to the handling of boats in river or canal traffic. These boatmen live with great economy upon the canal boat and seem to be contented with comparatively small gains and with conditions which would not be regarded favorably in the United States. In most cases towage is accomplished by horses, which are often stabled in the boats, but in numerous instances canal boats are towed by men. Steam and electric traction is restricted mainly to larger boats and trains of tows.

5. *Engineering difficulties.*—Engineering difficulties, as a rule, on those rivers which are most utilized, are less serious on the rivers of Europe than in the United States. The most notable example of this is the River Rhine. Its sources are in the Alps, where the melting of snow and ice during the hot weather of summer furnishes a constant supply for the water flow of the river at the very season when rivers are likely to be lowest in the United States. Furthermore, it should be said that conditions as regards alluvial banks, and shifting bars due to deposits of silt, are on the whole more favorable to river improvement in Europe than in the United States, and especially so upon rivers whose improvement would be most useful.

6. *The different relations between railways and waterways.*—Military considerations have been much more regarded in Europe, not only in the construction but in the management of transportation lines, than in the United States. Railways are laid down to connect the center with the frontier, or, at any rate, are located with a view to the mobilization of troops and to the carrying of supplies to places where they may be needed, and with a less uniform regard for serving great manufacturing centers or populous cities. Waterways are located mainly with a view to the development of trade at all times and to relieving the railroads in time of war.

Sedulous care is taken by most European countries for the protection of inland water-borne traffic against railway competition. In France this is accomplished by enforcing a differential of 20 per cent in favor of the waterways as against railways, with the evident intention of maintaining both methods of transportation. In a majority of the other countries in which water transportation has reached its highest development the railways wholly or partially belong to the state. This is true in Germany, Austria, Hungary, Holland, and Belgium. The well established policy in these countries is to secure cooperation between railways and waterways by official control of railway rates, with a view to maintaining profitable traffic on the latter. The following tables, compiled from Volume VI of the Report of the Royal Commission on Canals and Waterways, show the comparative mileage and the comparative tonnage of the railways and waterways of Belgium, France, and Germany:

BELGIUM.

Year.	Length (in miles).		Tonnage (in 1,000 tons).	
	Waterways.	Railways.	Waterways.	Railways.
1888	998.4	2,364.7	24,836	40,352
1890	1,018.2	2,378.4	25,242	42,990
1895	1,009.7	2,407.8	30,242	46,664
1900	1,015.6	2,881.2	38,178	55,108
1903	1,015.6	2,874.4	49,020	59,297
1905	1,015.6	2,873.8	53,345	65,319

FRANCE.

1880	6,782	14,315	18,000	80,774
1885	7,676	18,500	19,573	75,192
1890	7,670	20,634	24,167	92,506
1895	7,614	22,469	27,174	100,834
1900	7,533	23,436	32,446	126,830
1903	7,589	24,149	33,340	129,305
1905	7,483	24,459	34,030	139,000

GERMANY.

1875	[a] 6,200	16,430	20,800	167,000
1885	6,200	22,940	27,600	200,000
1895	6,200	27,780	46,700	331,000
1900	6,200	30,750	73,000	487,000
1905	6,200	33,730	103,400	588,700

[a] Although new waterways, with a length of several hundred miles, have been constructed since 1875, other waterways aggregating about the same length, have entirely lost their importance and are therefore excluded, so that the total length is accepted as unchanged. If all abandoned or insignificant lines are included, the total length of German waterways may be estimated at from 7,709 to 8,500 miles.

In 1906 the length of the railways of the United States was 222,571 miles, about 7.7 times the estimated length of all its navigable canals and rivers as given on page 28. The total tonnage of the railways in 1904 amounted to 1,631,374,219 tons. This was 12.3 times the estimated traffic of all the navigable rivers and canals in the United States, amounting to 132,000,000 tons.[a]

The success of water transportation in Europe is often attributed to the fact that railroad rates are higher abroad than in the United States. In a later report, the commission will endeavor to set forth a careful comparison between the freight and passenger rates of European countries and those of the United States. Frequent errors have been made in the past in comparing the average rates per ton per mile, owing to the different methods of handling traffic and of determining rates, resulting in erroneous and confusing conclusions. In Belgium, for instance, the cost of collection and delivery is included in the railroad rate, while in England such freight as is carried by express companies in this country is carried by the railroads directly. The average length of haul in this country is far greater than in Europe, owing, in some measure, to the smaller political divisions abroad. This tends to reduce the average cost per mile in this country. A proper comparison must be between specific commodities carried for specific distances, and under similar regulations as to the method of handling, and must take into account the comparative cost and effectiveness of labor, and also the cost of materials used, in the two cases.

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[a] W J McGee, Our Inland Waterways, in Popular Science Monthly, April, 1908.

Moreover, the railroads of Europe realize a much larger share of revenue from passenger traffic. Consequently, on the majority of their lines a greater degree of attention is paid to the handling of fast passenger trains, and this necessarily diminishes the efficiency of freight service. It has been stated in a document transmitted to the commission that the average time during which a freight train is operated in Prussia is only three hours per day, the cars being on side-tracks and in yards the remaining twenty-one hours. It should be conceded in this connection, however, that in some cases the efficiency of freight service and the number of hours of actual running time per day is no greater in the United States than in Europe.

While recognizing the necessity of more thorough investigations of the results of all these different factors, the commission would call attention to the fact that the average European freight rates on railway lines paralleling water routes, especially for short distances, are higher than those on lines similarly situated in the United States, and also that the European rates for water-borne carriage, in some instances even where the traffic is very large, are as high or higher than on railways in the United States in localities where traffic is likewise large.

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MEMORANDUM OF THE BOARD OF ENGINEERS FOR RIVERS AND HARBORS IN CONNECTION WITH E. D. 7288 AND CIRCULAR LETTER OF JULY 27, 1909, BASED THEREON, RELATING TO CAUSES OF DECLINE OF WATER TRANSPORTATION.

[Transmitted by the Chief of Engineers.]

In considering the causes which have led to the decline of water transportation, where it has occurred, a decline is deemed to exist not only in those cases in which records of tonnage show an actual decrease, but also in those in which the records show an increase not in proportion to the increase in the general commerce or business of the community.

An example of the latter class is furnished by the coal shipments by water to Cincinnati, which have not increased in proportion to the consumption of coal in that city.

The prevalent cause leading to the decline of water transportation is without doubt the railroad. The railroad corporation of large resources and facilities for its business successfully competes with navigation companies or individual boats with limited resources and facilities; and, competing, naturally does not enter into such relations with its competitor as to increase the business of the latter, declining to prorate, or to recognize through bills of lading. Moreover, railroads have established rival boat or barge lines through which competition has been discouraged. (Delaware and Raritan Canal, controlled by Pennsylvania Railroad; Allegheny Valley Railroad; Long Island Sound by both Pennsylvania and New York, New Haven and Hartford railroads; and generally on Atlantic and Pacific coasts and Great Lakes.)

The lower boat transportation rate does not measure the cost of water transportation. To it must be added charges for wharfage, teaming, and insurance; boat transportation on smaller streams is characterized by exposure of merchandise to the elements while on the bank awaiting or discharged from, the boat; shipments transferred to or from rail routes must be handled in detail; time schedules, affecting passenger traffic deranged often by low water and at times by high, are frequently uncertain; freight, on the contrary, is often delivered more quickly by water; capacity of boats may be insufficient to provide transportation as needed; recompense for damages to freight in transit difficult to determine in amount or to collect.

Enumerating the above serves to accentuate the advantages of rail transportation even at a higher first cost. In place of wharfage charges, and exposure of merchandise to the elements, is the railroad freight house, or it may be the car on a siding, minimizing or even abolishing teaming. Carloads are transferred from one line to another without handling of freight; less than car loads, without teaming. Increase in freight is met by increase in cars; time schedules are independent of water stages as a very general rule.

But water transportation must contend with not only the greater facilities of rail, but also with rail rates so low as to make movement of freight by water unprofitable. Water competition renders imperative what is well known as the long and short haul clause; and rail rates to meet such competition paralyze water transportation. The boat line bankrupted, the rail rate may be raised, for the water competition is no longer actual but constructive only. The rail rate itself is not necessarily unreasonable; it is held to be destructive and in restraint of trade when so low as to cause a loss to the railroad company. There may be cases, though none is known, where a rate has been held to cause a loss; though but one case is known where a rate to an inland point involving much shorter haul than to a water point has been declared unreasonably high by comparison with the rate to the water point, even though the latter rate cause no loss to the railroad company.

Railroads have also caused a decline in water transportation by centering such transportation about special points with greater facilities, natural and artificial, for greater vessels. Examples of this are to be found on the New England coast; and farther south, Norfolk has displaced Richmond and West Point. And here it may be fitting to note that water transportation has its fullest development on the Great Lakes and in the waters of and along the coasts of the United States when forming links in a chain of joint rail and water traffic.

But the essence of this fullest development is a capacious waterway; and this develops another cause for the decline—the intermittent character of the work of improving waterways. Contrast the improvement of the Ohio River with the construction of the Panama Canal. Both works are covered by comprehensive plans for definite results; but for the canal, appropriations are limited only to the extent of their possible due use.

But having in mind the Mississippi River, it does not appear that when navigable depths are available, they would be utilized to the extent of the greatest possibilities afforded. Streams are not used to their fullest or best advantage. The demand is often for greater depths, instead of adapting draft of boats to prevailing depths. Once lower competitive rail rates have been secured, traffic is diverted to the railroad, but in such cases the object desired by the community—the reduction of cost of transportation—has been secured.

Causes of local decline more or less widespread, yet well defined, are exhaustion of lumber (several localities); falling off of mackerel (Maine); abandonment of special manufactures, as salt and flour (Muskingum River); substitution of artificial for natural ice (a few localities); decline in use of "brown stone" (Connecticut River); demand for cotton by local factories (Savannah River).

In one case decline is in part due to a large industrial corporation declining, except in isolated cases, to ship its products by water (Ohio River).

In substituting the above memorandum, it is desired to invite attention to the fact that so far as data examined show, there has been no case where decline has been due to failure of the works of the department to produce improvement in navigable capacities when requisite funds have been supplied.

THE DEVELOPMENT OF SEAPORTS AND INTERNAL WATERWAYS.

THE NAVIGATION OF THE YANGSTE AND THE AMAZON.

[By Admiral C. S. Sperry, U. S. Navy.]

In discussing the proper development of commercial harbors and their facilities and the symmetrical development of the tributary internal waterway systems, it is advisable to consider, first, the development of the ocean carrier which is in progress and the conditions by which it is governed, recollecting that the same conditions do not govern the development of vessels navigating sheltered and narrow inland waters or rivers with strong currents and sharp bends. River boats and light draft barges of great beam, singly or in tows, can navigate such waters more safely and economically than a vessel built on the lines of an ocean carrier.

The necessary characteristics of the most economical ocean carrier can not be better stated than by quoting from a paper on "Maritime commerce, past, present, future," by Elmer Lawrence Corthell, M. A. Dr. Sc., civil engineer, read before the American Association for the Advancement of Science, August, 1898:

> Draught of water for the steamships of the present and future is the desideratum to which urgent attention should be called by all those who desire the continued development of commerce and the still further cheapening of transportation and a greater reduction in prices.
>
> I can not state this important condition that confronts us any better than in the words of one of the leading naval architects of the world, Dr. Francis Elgar, the consulting naval architect of the Great Fairfield works on the Clyde, and the designer of the *Campania* and *Lucania*. In a paper entitled "Fast ocean steamships," read before the Institution of Naval Architects in 1893, not long after these ships were built, he used these words (the italics are our own):
>
> "Deep draft of water.—This is a most important element of speed at sea, and it is now strictly limited by the depth of water in the ports and docks used by the fast passenger steamers on both sides of the Atlantic. Twenty-seven feet is the extreme limit of depth to which a ship can load on either side. The *Campania* can not load an inch deeper than the *Umbria*, although she is 100 feet longer. If the underwater dimensions of *Campania* had been increased proportionately to those of *Umbria* her draft of water would have been 32½ feet. This class of steamer is increasing in length and breadth, but the draft of water has to be kept the same. The result is that it is only a question of time, and not of a very long time with our present materials of construction and type of propulsive machinery, to find an absolute limit of speed imposed by the restriction of draft of water.
>
> "It is not only that the present limited draft of water will finally impose an absolute limit of speed, other conditions remaining the same, but it has already a very prejudicial effect in keeping down speed at the point actually reached. If the draft were not restricted, the form of section could be improved by giving to it more rise of bilge and an easier curvature. * * *
>
> "As the displacement is increased by increase of draft, the power required to drive a ton of displacement at a given speed becomes reduced. Hence increase of draft does not mean a proportionate increase of engine power, even when such increase is obtained merely by extra immersion without any improvement of form such as would otherwise be possible.
>
> "The advantages of increased draft would be felt still more in a seaway than in smooth water, as the lower part of the hull would be less affected by the wave surface and better and more constant immersion could be given to the propellers. * * *
>
> "The Atlantic trade is increasing at such a rapid rate that larger and swifter ships are certain to be soon called for. The depth of water has lately been somewhat increased at Liverpool; but much deeper harbors and docks will be required if further great increases of speed at sea are to be obtained without excessive difficulty and cost. * * *

"The opinion of practical navigators and of commercial men handling large vessels is that the inability to provide the depth of channels and harbors necessary to increase the draft of large freight carriers is very detrimental to good navigation and economical transportation.

"As vessels increase in size they have to be built as flat as possible to allow them to enter the harbors, which injures their sea-going qualities and renders them more dangerous and unwieldly, as well as more liable to injury from their shape. * * *"

It appears from these statements that, as the displacement of an ocean carrier is agumented by increasing the draft and other dimensions symmetrically, the power required to drive a ton of displacement at a given speed is reduced, which lessens the necessary expenditure for coal and operating force per ton of cargo carried. A modern ocean carrier of 5,000 tons displacement requires 1,000 indicated horsepower to drive her at a speed of 10 knots, and a carrier of the same type symmetrically enlarged to 10,000 tons displacement requires only 1,587 horsepower to drive her at the same speed; that is, the cargo-carrying capacity is doubled at the same speed with an increase of little more than 50 per cent for fuel. The increased expense for labor is less than 1 per cent and the superiority of the large carrier in adverse weather is very marked. A small, light-draft steamer in rough water is thrown about by every wave; her way is deadened by pitching into a heavy sea and her engines are always in danger of breaking down, owing to the racing of the propeller as her stern rises out of the water. Consider also that both the small ship and her cargo are liable to serious damage by heavy rolling and the shipping of water on her low decks, and the reason why the tonnage of the ocean carrier increases so steadily and keeps so close to the available depth of water at the harbor entrance is sufficiently apparent.

Lloyds Register of British Shipping shows that in 1893–94 there were only 87 steamers of and above 5,000 tons, while in 1908–9 there were 599, and during the same period the steamers of 3,000 tons and above 2,000 tons decreased in number from 1,277 in 1893–94 to 1,013 in 1908–9. The eagerness with which the size of steamers follows the available depth of water is shown by the fact that the White Star Line is now building the *Olympic* and *Titanic*, with a draft of 37½ feet on a displacement of 60,000 tons, to take advantage of the new 40-foot channel into the port of New York.

The report of the Chief of Engineers, U. S. Army, 1907, states that the lowering of freight rates at Boston during the last fifteen or twenty years has been about 50 per cent, and that the deepening of the harbor of Savannah has lowered the rates at that port from 30 to 50 per cent. A memorandum supplied by the Savannah Chamber of Commerce in November, 1909, states that the increase in the size of ships at that port, owing to the increase of the depth of the channel to 22 feet at low water, has been 40 per cent in the last ten years, and that during the same period marine insurance has fallen 25 per cent and freight rates 37 per cent.

The very great economy of the large ocean carrier sufficiently explains the activity with which such great ports as New York, Liverpool, London, Shanghai, and a host of lesser ports are being improved the world over, while the great ship canals, Suez and Kiel, are being steadily deepened; but it is evident that long lines of canals, or even such rivers as the Amazon and the Yangtse, owing to the great labor involved, can not be improved commensurately, and therefore the most economical long-distance ocean carriers can never use them. Nor, conversely, can even the largest of the vessels using our inland waters, deepen and improve the waterways as we may, ever navigate the high seas economically or safely as compared to an ocean carrier of to-day of even moderate proportions.

Certain artificial waterways will always be used even though the size of vessels navigating them may be, to a certain extent, limited, and to this class belong the Suez and Panama canals.

The Suez Canal, 87 miles in length, shortens the route for the vast commerce from northern and western Europe to Calcutta by 3,700 miles and to Hongkong by 3,300 miles, as compared to the routes by the Cape of Good Hope and the Straits of Sunda; and although vessels now using the canal are limited to a draft of 28 feet the canal is being deepened to take vessels drawing 31 feet, and even the greater economy of the larger freighter will not justify the expense of the longer voyage around the Cape. The same conditions make it certain that the Panama Canal, 49 miles long, with a designed depth of 41 feet, will be used by ocean carriers. The west coast of South America is in the same longitude as the Atlantic seaboard of the United States, and, with trifling deflections about Cuba, the course from New York to Callao is nearly a straight line. From New York to Callao via the Panama Canal the distance is 3,400 miles. From the entrance to the English Channel to Callao by the same route it is 6,500 miles. From the channel to Callao via the Straits of Magellan it is 10,100 miles. From New York to San Francisco via Panama the distance is 8,050 miles less than via the Straits of Magellan. The trade route for large carriers from Europe to Valparaiso may continue through the Straits of Magellan, because of the great ports of call on the east coast of South America, but the trade of the northern ports on the west coast will inevitably pass through the canal, and that short and cheap route for vessels of the largest class must develop a great trade between the east coast of the United States and the west coast of South America. The fertilizer nitrates and other products of the coast should come north in exchange for the lumber, manufactured cotton, and other goods and coal of the Atlantic States.

The considerations which force the use of the Suez and Panama canals are manifest.

The Kaiser-Wilhelm, or Kiel Canal, connects the North Sea with the Baltic, and is 53 miles in length. The saving in distance for vessels bound from the English Channel to the Baltic is about 200 miles and the navigation of the narrow waters about Denmark is avoided. The canal can now take vessels of the largest class, but is being still further deepened in view of the increasing size of war vessels. The principal motives of the German Government in building the canal were undoubtedly military and strategic, the commercial aspect being incidental. The least depth of water encountered by vessels passing into the Baltic through the Great Belt, or route to the north and east of Denmark, is 36 feet.

The total number of steamers, barges, and sailing vessels carrying cargo, or in ballast, using the Kiel Canal, and their tonnage, are given in the Great Canals of the World, Department of Commerce and Labor, 1895 to 1904, and in Statistiches Jahrbuch für das Deutsche Reich, edition of 1909, for remaining years, as follows:

Year.	Number of vessels.	Tonnage.
July 1, 1895, to June 30, 1896 (the first year after opening)	16,834	1,505,983
1898	23,108	2,469,795
1900	26,279	3,488,767
1902	30,161	4,285,301
1904	32,038	4,990,287
1906	34,187	6,045,963
1908	34,121	6,012,178

The Corinth Canal, connecting the Gulf of Corinth with the Gulf of Aegina, is less than 4 miles long and shortens the voyage from the Adriatic by 170 miles, and from the Mediterranean by 100 miles, but the Mediterranean Pilot, B. A., fourth edition, p. 51, states:

> None of the foreign steamship companies navigating the Mediterranean now use the canal. It is mostly used by small Greek passenger steamers.

It can be navigated by vessels not drawing more than 23 feet 6 inches, but, owing to the troublesome winds and currents and the narrowness of the channel, the use of one or two tugs is necessary, even for steam vessels, to keep them from grounding. These drawbacks account for the little use made of the canal, and it is well to consider the general conditions under which large vessels navigate canals. If the draft of the vessel approaches very near to the limit fixed by the depth of the channel, the suction is so great, owing to the little water between the ship and the bottom of the canal, that the vessel will obey the helm very sluggishly and sometimes not at all, even if there is neither wind nor current, and an instant off the course in a narrow channel will put the vessel aground. The propellers are very likely to be damaged under such circumstances, which is a serious matter for the ship, and if the vessel continues aground for any length of time the traffic on the canal is tied up and the loss to all parties is very heavy. Such accidents add to the expense of operating the canal and must be considered in adjusting the tolls, and as they also add to the ship's expenses they must be considered in rates of freight and insurance.

In regard to such canals as the St. Marys, connecting Lake Superior with the chain of lakes to the east and south, it is obvious that, as there is no alternative, vessels must use them, and owing to the economy of large vessels many of them are of such size that for a portion of their route over connecting waters of the Great Lakes there is at times no more than 6 inches of water to spare—so narrow a margin is only possible in tideless waters with little seasonal variation in height, and the possibility of poor steering is contemplated and met by additional care because of the economy of the larger vessel or barge.

The Welland Canal through Canadian territory takes vessels drawing not more than 14 feet, and with a length of 26¾ miles has 26 locks. It is the only available water route between Lakes Erie and Ontario; but the great body of the traffic on Lake Erie being destined for the middle and eastern United States naturally proceeds by rail or through the Erie Canal, thus lessening the traffic through the Welland Canal.

A canal from Chicago to Toledo, via Fort Wayne, would be about 250 miles in length, and the passage via the Straits of Mackinaw between the same points is about 700 miles, but it seems certain that large lake carriers would not use a canal between those points. The speed of a large carrier could not possibly exceed 5 knots, less than half the speed in open water, unless the depth were more than 3 feet greater than the draft of the vessel, and the power required to drive a large vessel in a canal is so greatly increased by the suction that there soon comes a point where the speed is practically constant, however great the power expended. Also, the danger of grounding in the case of a large carrier steering badly in shallow water and causing delays and blockade is very considerable. Any use of the canal except for local traffic by barges would probably be exceptional.

The traffic in certain canals of no great length, which permit ocean carriers of more or less limited draft to reach important commercial centers, shows some increase, as in the case of the Manchester Canal, 35½ miles in length, with a least depth of 28 feet, and the Bruges Canal, 7 miles in length, with a least depth of 26 feet. (Port of Manchester Official Sailing Ship List Guide, July, 1909, p. 90, and North Sea Pilot, B. A., 1909.)

The sea-borne traffic of the Manchester Canal in 1898 was 2,218,005 tons, and in 1905 it was 3,993,110 tons. (Royal Commission on Canals and Inland Navigations, Vol. IV, 1908, p. 80.)

At Bruges the number of vessels entering in 1900 was 101, tonnage 30,785 tons; in 1905 it was 151, tonnage 49,022 tons; and in 1908 it was 576, tonnage 321,067. (Tableau General du Commerce Etranger, Belgium 1908, p. 692.)

The limit of the use of most canals by ocean carriers is speedily reached, but the particular conditions are local and various. In the North Sea and the English Channel, the sea portion of the route rarely exceeds twelve hours, and the economy of the carrier of limited size making the continuous voyage lies in the fact that one handling is saved by proceeding direct to such a port as Bruges, but if the canal is long the delays of navigation, ordinary or due to casualties, are such that transshipment with proper terminals will be speedier and more economical.

The Seine has been so improved that Rouen is practically the seaport of Paris. The distance from the outer limit of the estuary of the Seine to Rouen is 71 miles, and vessels drawing 19 feet can ascend to that place at high-water neap tides, and vessels drawing 25 feet can ascend at high-water springs. The size of vessels frequenting the port is increasing. In 1905, 1,482 vessels, with a tonnage of 1,051,562 tons, entered the port. (Channel Pilot B. A., 1906.)

NAVIGATION OF THE YANGTSE.

The navigation of the Yangtse is at all times difficult, and pilots who travel the river constantly are a necessity, as the changes are so frequent that charts can not be depended on. In summer when the river is high the banks are generally flooded and the strong current makes navigation dangerous. When the river has subsided the channels are completely changed, and shoals and bars have formed and new passages have been cut through where none existed.

The highest water occurs between June and October, and the height of the summer above the winter levels may be considered to be for Chinkiang, 190 miles from the sea, 15 to 18 feet; Kiukiang, 450 miles from the sea, 30 feet, and for Hankau, 600 miles from the sea, 40 to 50 feet. At the highest water, in July and August, the higher portions of the river have the appearance of an immense lake, and at many places between Nanking and Hankau the waters exceed 20 miles in width. Sometimes no land can be seen from the deck on either hand as far as the distant hills.

The great treaty port of Shanghai lies on the Wusung River, which enters into the Yangtse about 20 miles from the sea, and is about 12 miles above the mouth of the Wusung. The entrance to the Yangtse is obstructed by bars and flats and heavy vessels can only enter at high water. Neaps ordinarily rise 10 feet and springs 14 to 15½, so that in ordinary weather vessels drawing from 26 to 30 feet may enter according to the state of the tide, but the tides are greatly affected by the winds, and with a strong wind from the westward, they are much lower. The extensive bar at the mouth of the Wusung is another obstacle, but usually vessels drawing 21 feet can reach Shanghai in the autumn, and drawing 24 or 25 feet in the spring. This necessitates lightering cargo at the Wusung bar, in many cases, as very large steamers frequent the port.

Shanghai is one of the chief commercial cities of the world. The population is about 350,000, of which 7,000 are foreigners in the settlements. In 1905, the total foreign imports at Shanghai were valued at £38,863,144, and the exports to foreign countries at £16,238,508. In the same year 5,156 vessels, with an aggregate tonnage of 7,195,000 tons, entered the port. In addition there is a large inland steam navigation trade. About 6,000 tons of coal and 4,000 tons of liquid fuel are usually in stock. For 50 miles around the city there is water communication with the interior in every direction by the numerous canals and creeks which intersect the province. There are numerous wharves where any vessels that are able to cross Wusung inner bar can lie alongside.

Nanking, 230 miles from the sea, can be reached at all times by vessels drawing 27 feet if they have been able to cross the bar at the entrance to the Yangtse.

Hankau, 615 miles from the sea, is the highest point of any direct foreign trade, of which there is no great amount, what there is being principally oil steamers of the Standard Oil Company. The bulk of the trade is by river steamers carrying cargo transshipped at Shanghai. There are eight lines of such steamers, affording daily communication. From June to October vessels drawing 27 feet can reach Hankau, but for the remainder of the year access is occasionally difficult for vessels drawing as little as 9 feet. At Hankau the river is a mile wide and during the summer it is inconvenient for vessels to lie far out, as the strong current makes communication difficult. Vessels are liable to the danger of being fouled by timber rafts, which sometimes during freshets break adrift from the banks higher up, where they are moored.

Ichang, about 980 miles from the sea, is the head of river-boat navigation for unbroken voyages, as above that point the Yangtse passes through narrow gorges and is obstructed by rapids. There is no direct foreign trade. Many river steamers not drawing more than 6 feet ply to Ichang, and there are about 12,000 junks for handling cargo transshipped for up-river trade.

At none of the towns above Shanghai on the Yangtse are there any wharves, nor are there any facilities for handling cargo except a plentiful supply of cheap coolie labor.

The latest type of river steamers on the Yangtse is a triple-screw steel steamer 250 feet long with 40 feet beam, and drawing, with an average load, 5½ feet. She is one of four steamers trading regularly from Hankau to Ichang and is supplied with a steam launch to precede the steamer and take soundings. Another steamer, the *Kiang Hsiu*, belonging to the China Merchants Company, is 325 feet long, 44 feet beam, draws about 7 feet, has twin screws, and was built in 1905. The first river steamers on the Yangtse were American side-wheel boats sent out for the purpose, but of late years the new screw boats of steel have been built at Shanghai. (Information principally from the China Sea Directory, B. A., 1904, Vol. III, and Supplement, 1907.)

Great plans for railway development in China, which have been debated for many years, seem about to be realized, in a measure, and they will doubtless stimulate the development of the hill country beyond the reach of the great canal system of the Yellow River; but Shanghai will continue to reap the benefit of the great canal and river system of which it is the center. It will be benefited very greatly if the Wusung bars are dredged to take vessels drawing 27 feet at all seasons—27 feet being nearly the maximum draft which can usually cross the bars at the entrance to the Yangtse, which are so wide that their improvement is not likely to be undertaken. The wharves of Shanghai at which vessels can lie already extend for several miles on both banks and can readily be greatly extended, so that as the channel is deepened shipping will be favored by the terminal facilities and still fewer ocean carriers will care to meet the strong currents and difficult navigation of the Yangtse.

NAVIGATION OF THE AMAZON.

The city of Para lies in the estuary of the Amazon and it had a population in 1899 of 120,000 people. In 1901 the exports, principally rubber, isinglass, cocoa, hides, nuts, tobacco, and deerskins, were valued at $14,000,000.

The following account of the port facilities of Para is taken from the weekly Hydrographic Bulletin, No. 1048, issued by the United States Hydrographic Office, Navy Department, September 29, 1909:

> *Para, Brazil.*—The entrance to the port is marked by the lightship and gas buoys; there are 21 feet on the bar at low water. The harbor is a good one, with a least depth of 20 feet, but the holding ground is poor. Pilots are necessary and are reliable; the charges are high. The chart used was the British Admiralty chart, a late issue; it is reliable. A limited amount of repairs to vessels' engines and dynamos can be made. Moderate sized castings can also be made. There is one floating dry dock; no wrecking appliances. There are no wharves. Cargo is handled with ship's gear, and the lighters are good up to 200 tons. Labor is negro, plentiful and cheap. Fresh and canned provisions can be obtained; the price is high. River water is used for drinking and boiler purposes. There is a hospital. There is telegraphic and rail communication to Bahia. There is a fair quantity of coal on hand; it is handled by lighters alongside. The money used is Brazilian; the rate of exchange fluctuates. No time or signal service. (From information furnished the Branch Hydrographic Office, New York, Aug. 23, 1909, through the courtesy of Mr. W. Leddin, chief officer of British steamer *Hyanthes*.)

It will be noted that the draft of vessels entering the port must be limited to about 20 feet, which restricts the ocean carriers at Para to a tonnage of about 2,000 tons, as appears from the following memorandum on the trade on the Amazon, prepared from the latest information available by Capt. A. G. Winterhalter, U. S. Navy, hydrographer:

> Steamers drawing 14 feet can navigate the Amazon for 2,700 miles above its mouth, or to Borja, 400 miles beyond Iquitos, Peru. The principal difficulty is due to the shifting bars, the strong currents, 3 to 5 knots, and the immense quantity of driftwood which comes down when the river is rising. Pilots are necessary and are regularly employed by companies operating river steamers.
>
> Manaos, about 900 miles from the mouth of the river, is the most important town above Para, and has both ocean and river trade. There is about 40 feet difference between high water and low water at this point.
>
> From Manaos to Iquitos, Peru, about 1,300 miles, there are no towns of importance. The difference between high and low water is about 18 feet at Iquitos.
>
> The following regular lines of steamers are engaged in the commerce of the Amazon:
>
> *Amazon Steam Navigation Company.*—Twenty-nine steamers, of 9,184 aggregate tonnage, ply between Para and points on the Amazon and tributaries.
>
> *Booth's Line.*—Thirteen steamers, from 1,100 to 2,000 tons each. Itineraries of these vessels include the following ports: Manaos, Liverpool, Havre, Lisbon, Madeira, New York, Maranhao, Ceara, and Barbados. Smaller vessels of this line go to Iquitos. Sailings every ten days from Manaos for Europe; every twenty days for New York.
>
> *Red Cross Line.*—Nine steamers; aggregate tonnage, 9,467. This line has same itinerary as Booth Line, dates of sailings alternating with those of latter line.
>
> *Lloyd Brazilian Line.*—Seven vessels, of 1,999 tons each, plying between Manaos and Rio Janeiro, and touching at intermediate points.
>
> *Ligure Brasiliana (Italian).*—Two steamers, plying between Manaos and Genoa, touching at Para and Mediterranean ports.
>
> *A. Berneaud & Co.*—Twelve steamers, of 150 to 300 tons each, navigating the Amazon, Madeira, Negro, Purus, and other tributaries.
>
> In addition to the above there are many river steamers owned by the rubber firms of Para, Manaos, and Iquitos. These firms have from one to eight steamers each, according to the extent of their business, engaged in taking up supplies to the rubber gatherers and bringing down cargoes of rubber. There are, perhaps, as many as 150 vessels of this description on the Amazon and its tributaries. There are no telegraph lines in the valley, nor communication of any kind other than by water. Efforts are being made to lay a cable from Para to Manaos. Communication between the upper Amazon and the Pacific is slow and difficult. From Iquitos to Lima requires about thirty days, twenty of which are by mule.

Manaos had a population of 40,000 in 1900 and is the terminus for the lower river steamers of the Amazon Navigation Company. In places above Para the river, although very deep, is only 38 yards wide from bank to bank, which, with a current, makes navigation by large vessels difficult and dangerous.

Iquitos, Peru, is distant, as the crow flies, about 540 statute miles from the nearest point of the west coast of South America, and about 400 miles from the crest of the Andean watershed which, between 4° south and 8° south, has a general height of about 6,500 feet. The Peruvian Government is projecting railways from the coast into the Andean region, and in view of the comparatively short voyage from the west coast via the Panama Canal to the Atlantic States, it is probable that the whole trade of Peru as it develops will take ship from the Pacific Coast rather than go via the Amazon and Para. The distance from Callao to New York via Panama is 3,400 miles. From the head of navigation on the Amazon to Para there are 2,700 miles of difficult river navigation, and from there to New York by sea the distance is 2,943 miles.

There seems to be no question that both on the Yangtse and on the Amazon the tendency is to handle traffic in river steamers of such light draft that they can work at all stages of the river, fast, easily handled, and capable of making river landings safely.

It may be said generally that the decrease in ocean freight rates is very great, as the size of the carrier increases; that at the great seaports, where cargoes are ample, the largest carriers which can enter will be employed, and that the system of internal waterways should be improved as rapidly as possible to supplement the railroads, but that transshipment at the seaport being a commercial necessity, however the goods may reach the port, development will be in vain unless ample terminal facilities are provided, so situated as to permit of indefinite expansion.

THE COMMERCE OF THE HUDSON RIVER.

[By Mr. E. O. Merchant.]

The commerce of the Hudson River consists principally of lumber, grain, ice, building materials, including brick, also fuel, including coal. There is also an extensive passenger and excursion traffic.[a] There has been a falling off in traffic since 1899, due partially to the decrease in ice shipments, the competition of railroads, and the decline of canal traffic. The total receipts and shipments for 1906 were estimated at 8,654,880 tons, of which 1,335,615 tons, or 15.5 per cent were miscellaneous merchandise.[b]

Commerce on the Hudson River at Albany.[a]

	General merchandise.	Total.	Percentage of merchandise.
	Tons.	*Tons.*	*Tons.*
1898	697,554	4,045,895	17.2
1899	730,809	5,070,800	14.4
1900	1,037,389	4,810,927	21.7
1901	776,908	3,123,409	24.9
1902	297,323	3,673,097	8.1
1903	546,527	3,486,419	15.7
1904	632,205	3,513,545	18.0
1905	256,846	3,310,628	7.8
1906	314,952	3,325,360	9.5

[a] Transportation by Water, Pt. II, pp. 69, 70.

In 1906 the total traffic at Albany was divided into the following percentages:

Ice	23.6
Lumber and timber	16.3
General merchandise	9.5
Vegetable food	10.6
Stone, cement, sand, etc	12.6
Fuel (wood and coal)	12.3
Miscellaneous	15.1

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[a] Transportation by Water, Pt. II, p. 69.

[b] United States Census Report on Transportation by Water, p. 209.

The most complete statistics of the local commerce of the Hudson are those collected by the United States Army engineers for the stretch of the river between Coxsackie and the state dam at Troy. These show that the amount of freight traffic here has declined nearly one-third within the last decade, while the passenger traffic has increased slightly. The variability of the figures for general merchandise, especially from 1900–1902, is due partially to the lack of uniformity. Beginning with 1902, manufactures and sundries were listed separately. Before this they were probably included in general merchandise. It was stated by the engineers during the years 1898–1900, that in addition to the local commerce the through commerce amounted annually to more than 10,000,000 tons.

Local river commerce between Coxsackie and state dam at Troy.[a]

	Total.	General merchandise.	Percentage of merchandise.	Passengers.
	Tons.	*Tons.*		
1898	4,045,895	809,746	20.0	771,196
1900	4,810,927	1,037,389	21.6	1,567,600
1901	3,123,409	776,908	25.0	1,293,236
1902	3,673,097	297,323	8.1	1,078,648
1903	3,486,393	546,527	15.7	1,044,254
1904	3,513,545	632,205	18.0	1,117,785
1905	3,310,628	256,846	7.8	1,222,473
1906	3,325,360	314,952	9.5	1,300,297
1907	2,881,168	435,640	15.0	1,266,008
1908	2,945,921	477,983	16.2	1,288,721

[a] Compiled from annual reports of Chief of Engineers.

THE MOVEMENT OF PACKAGE FREIGHT ON THE GREAT LAKES.

[By Mr. E. O. Merchant.]

No exact statistics are available for the movement of package freight through the Great Lakes, although some general idea can be arrived at by an examination of the figures for general merchandise, miscellaneous freight, miscellaneous merchandise, and unclassified freight. Package freight corresponds roughly to what is meant by general merchandise, and is included, as a rule, in the statistics given for the miscellaneous and unclassified freight, so that it is safe to say that in no case would the percentage of package freight be greater than the percentage of these several classes, and more often it would be considerably less.

The great artery of lake commerce is the route from Lake Superior through the St. Mary canals, Lake Huron, St. Clair River, St. Clair Flats Canal, which is a channel at the upper end of Lake St. Clair, St. Clair Lake, and the Detroit River to Lake Erie. Over this route passes the enormous shipments of iron ore eastward, and coal westward. In comparison with the shipments of these two commodities, the relative amount of package freight is very small, though in number of tons it is fairly large, as the following table will show. Careful statistics are collected by the United States Army Engineers at the Sault Ste. Marie canals and these give the best index of the amount of traffic passing over this main route. The American canal, built by the State of Michigan, was opened in 1855. It has twice been enlarged by the United States Government, so that since 1896 it has permitted the passage of vessels of twenty feet draft. The Canadian Canal, constructed by the Canadian government, was opened in 1895, The following table shows the amount of general merchandise and the total traffic passing through these canals since 1885 for seasons ending December 31:

Canals at Sault Ste. Marie.[a]

Year.	General merchandise.			Total shipments, eastbound and westbound.	Percentage of general merchandise.
	Eastbound.	Westbound.	Total.		
	Tons.	*Tons.*	*Tons.*	*Tons.*	
1885			184,963	3,256,628	5.7
1890			371,294	9,041,213	4.1
1895			463,308	15,062,580	3.1
1900	86,333	455,064	541,397	25,643,073	2.1
1901	79,723	478,318	558,141	28,403,065	2.0
1902	122,248	617,852	740,100	35,961,146	2.1
1903	92,486	567,353	659,839	34,674,437	1.9
1904	95,374	636,635	732,009	31,546,106	2.3
1905	100.357	736,226	836,583	44,270,680	1.9
1906	150,586	984,265	1,134,851	51,751,080	2.2
1907	106,075	916,579	1,022,654	58,217,214	1.8
1908	110,238	732,663	842,901	41,390,557	2.0
1909	163,159	977,185	1,140,344	57,895,149	2.0

[a] Compiled from the annual reports of the Chief of Engineers and the Monthly Summary of Commerce and Finance.

The following are the percentages of the principal commodities passing through the Sault Ste. Marie canals in 1907:[a]

Commodity.	Per cent.	General direction.
Iron ore	68.0	Eastbound.
Coal	19.6	Westbound.
Flour, wheat, and other grains, of which 5.1 was wheat	8.0	Eastbound.
Lumber	1.9	Do.
Salt, pig iron, copper, etc	.7	
General merchandise	1.8	East and west bound.[b]
Total	100.0	

[a] Transportation by Water, Part II, pp. 208-211.

[b] Of the traffic in general merchandise in 1907, 89.5 per cent was westbound and 10.5 per cent was eastbound.

The total eastbound shipments through these canals average four times the westbound, owing to the enormous iron-ore traffic.

No statistics of traffic passing through the St. Clair Flats Canal and Detroit River are collected, but the number of vessels and their registered tonnage are recorded, from which, by a comparison with the statistics of St. Marys canals, estimates of the total traffic and value thereof are computed. The amount of traffic passing through the Detroit River averages from 25 to 28 per cent greater than that through the Sault Ste. Marie canals. The traffic through the St. Clair Flats Canal averages somewhat less than through Detroit River, which is to be expected, since Lake St. Clair and the head of Detroit River absorb much more Lake Erie coal coming through Detroit River than they do Lake Superior ore coming through St. Clair River and the Flats Canal.

The following table shows the domestic traffic passing through the Detroit River for the last three years. The totals are somewhat smaller than those for both domestic and foreign.

Domestic traffic through Detroit River.[a]

	Miscellaneous.[b]			Total shipments southbound.	Total traffic northbound.	Total all shipments.	Percentage of miscellaneous.
	Southbound.	Northbound.	Total.				
	Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	
1906[c]	966,738	1,303,042	2,269,780	44,129,343	16,448,812	60,578,155	3.7
1907	1,053,090	1,299,766	2,352,856	46,966,193	20,326,311	67,292,504	3.5
1908	1,402,900	1,011,683	2,414,583	29,260,914	17,685,970	46,946,884	5.1

[a] Monthly Summary of Commerce and Finance, December, 1908, the tonnage being estimated as that passing a point near the center of Detroit's water front.

[b] The figures for general merchandise and package freight would be somewhat smaller.

[c] Only totals are obtainable before this date.

Lake Erie stands first among the Lakes, both in volume and value of its total traffic. At its ports are received practically all the grain and flour shipped to American ports and nearly 80 per cent of the iron-ore movement, and from Lake Erie ports are sent the great bulk of coal shipments. While primarily a lake of receiving ports, the coal shipments and miscellaneous package freight bring the volume of shipments on Lake Erie above those on Lake Michigan.[a] At a majority of the Lake Erie ports, it appears that the receipts of general merchandise exceed the shipments, and it also appears that there is an extensive interchange of general merchandise between ports. Cleveland, especially since 1902, seems to be the most notable exception, as the following table will show. At Sandusky, Ohio, and Buffalo the shipments of general merchandise also somewhat exceed the receipts.

Lake commerce at Cleveland.

Year.	Merchandise and other articles.			Total receipts.	Total shipments.	Total receipts and shipments.	Percentage of merchandise.
	Received by lake.	Shipped by lake.	Total.				
	Tons.	*Tons*	*Tons.*				
1895	65,464	94,374	159,838	3,593,044	1,608,313	5,201,357	3.0
1896	53,315	99,121	152,436	3,475,281	2,047,285	5,522,566	3.0
1897	76,680	134,809	211,489	3,623,001	2,378,347	6,001,348	3.5
1898	78,439	161,488	239,927	4,038,684	2,461,834	6,500,518	3.7
1899	60,216	142,743	202,959	4,769,720	2,621,201	7,390,921	2.9
1900	113,671	142,749	256,420	4,820,597	2,548,826	7,369,423	3.5
1901	66,219	168,563	234,782	5,410,277	2,089,817	7,500,094	3.1
1902	74,024	722,405	796,429	5,799,420	3,059,603	8,859,023	9.0
1903	88,161	638,451	726,612	5,240,828	3,518,985	8,859,813	8.2
1904	84,353	596,694	681,047	4,477,172	3,841,738	8,318,310	8.2
1905	90,742	615,974	706,716	6,749,262	3,494,866	10,244,128	6.9
1906	89,181	615,769	704,950	5,575,473	3,807,111	9,382,584	7.5

The following tables, compiled from the annual reports of the Chief of Engineers, show the domestic commerce at Duluth. The percentage of general merchandise to total receipts and shipments is very small, as shown by the first table. The reason for this is the predominance of coal in the receipts and of iron ore in the shipments, as shown by the second table.

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[a] Transportation by Water, Part II, pp. 233 and 234.

Domestic commerce at Duluth.

	General merchandise.			Receipts and shipments—all commodities.	Percentage of general merchandise.
	Received.	Shipped.	Total.		
	Tons.	*Tons.*	*Tons.*		
1900	112,230	52,996	165,226	7,089,441	2.3
1901	115,644	41,187	156,831	6,851,729	2.3
1902	[a] 142,267	45,496	187,763	9,175,593	2.0
1903	[a] 122,447	34,625	157,072	9,002,530	1.7
1904	[a] 96,954	29,248	126,202	8,024,319	1.6
1905	[a] 129,484	35,749	165,233	13,139,541	1.3
1906	[a] 154,030	42,235	196,265	16,518,200	1.2
1907	[b] 242,481	[b] 49,139	[b] 291,620	[b] 34,786,705	.9
1908	[b] 194,785	[b] 34,743	[b] 229,528	[b] 23,797,162	1.0

[a] Includes about 2,500 tons of fish.

[b] Duluth and Superior combined.

Domestic receipts and shipments at Duluth.

	1900.	1901.	1902.	1903.	1904.
	Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*
Receipts	1,234,119	1,248,526	1,291,357	1,599,402	1,617,581
Coal receipts	958,286	955,427	905,915	1,281,930	1,350,544
Shipments	5,854,322	5,603,203	7,884,236	7,403,128	6,406,738
Iron ore	4,270,429	3,836,553	6,198,043	5,939,575	5,147,028

	1905.	1906.	1907.	1908.
	Tons.	*Tons.*	*Tons.*	*Tons.*
Receipts	1,755,501	2,094,099	7,840,023	6,594,915
Coal receipts	1,397,788	1,601,166	7,037,179	5,805,703
Shipments	11,384,040	14,424,101	26,976,682	17,202,247
Iron ore	9,766,815	12,498,033	23,590,969	14,064,633

The low percentage of general merchandise to total traffic along the main route from Lake Superior to Lake Erie is, in all probability, somewhat misleading as to the actual amount of this kind of traffic carried on the Great Lakes. There is an extensive local business on Lake Erie, as already indicated, and also on Lake Michigan, which can not be estimated. If we leave the main channel, the percentage of general merchandise rises at once, as the following tables show:

Portage Lake Ship Canal.[a]

	General merchandise.			Total up and down shipments.	Percentage of the whole.
	Bound up.	Bound down.	Total.		
	Tons.	*Tons.*	*Tons.*	*Tons.*	
1900	180,474	42,465	222,939	1,867,772	11.9
1901	124,389	19,480	143,869	2,114,385	6.9
1902	166,486	18,721	185,207	2,532,323	7.3
1903	166,737	15,723	182,460	2,420,848	7.5
1904	116,606	9,651	126,257	2,295,922	5.5
1905	163,107	20,559	183,666	2,462,910	7.4
1906	204,407	20,717	225,124	2,602,044	8.6
1907	164,967	19,492	184,459	2,496,336	7.4
1908	166,904	23,432	190,336	2,300,124	8.2

[a] Compiled from the annual reports of Chief of Engineers and the Monthly Summary of Commerce and Finance.

Traffic through Sturgeon Bay and Lake Michigan Canal.

	General merchandise.			Total, all commodities.	Percentage of merchandise.
	East.	West.	Total.		
	Tons.	*Tons.*	*Tons.*	*Tons.*	
1907	18,169	40,208	58,377	775,496	7.5
1908	19,242	36,474	55,716	692,613	8.0

METHODS OF FINANCING THE CONSTRUCTION AND IMPROVEMENT OF WATERWAYS IN EUROPE.

[By Mr. E. O. Merchant.]

BELGIUM.

Many of the Belgian waterways were constructed at an early period, so that the details of their construction are not always definitely known. At the beginning of the nineteenth century they were under French influence, and their present administration, procedure of obtaining funds, etc., is somewhat similar to the French system.

The total length of the Belgian waterways is 1,345 miles, of which 330 miles are of little importance. The total length of the main lines is 1,015 miles, of which 900 miles belong to the State and 115 to the Provinces, communes, or concessions.[a] During the period 1820–1830 there were 1,005 miles of waterways, of which 10 per cent belonged to the State, 64 per cent to the Provinces, 7 per cent to the communes, and 19 per cent to concessions. Shortly after this the State began to acquire the lines and buy up the various concessions, so that in the period 1860–1870 the State owned 83 per cent of the waterways, which then measured 1,220 miles. The Provinces owned 7½ per cent, the communes 4½, and concessions 5 per cent.[b]

At the present day, with the exception of a few lines constructed under concessions, the navigable waterways in Belgium may be considered as state owned. The important concessions remaining are:[b]

(1) The canalized Dendre, with Ath-Blaton Canal, owned by a private company.

(2) Rupel-Brussels Canal, owned by an association of the various communes along the line, in which the commune of Brussels has the largest financial interest.

(3) The Dyle-Louvain, owned by the commune of Louvain.

The inland harbors of commerce, ports, and wharves are owned and administered by the municipalities, Provinces, and communes, and in the mining and industrial districts by the interested parties. The harbors of refuge and some harbors of commerce, especially constructed, are owned by the State. The capital necessary for the construction and maintenance of the state waterways is provided out of the ordinary budget revenue. The expenditure was formerly largely met by tolls, which from 1840 to 1860 not only covered the cost of improvement and maintenance but also afforded a surplus for interest on the cost of construction.[a] The tolls have been considerably reduced since that time, but still cover a part of the cost of current improvements and maintenance, which in 1905 amounted to about $440,000, not including cost of personnel.[b] When the interest on the capital invested at 3½ per cent is added to the deficit from maintenance the total annual charge to the State is about $2,740,000.

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[a] Report of the Royal Commission on Canals and Waterways, Vol. VI, p. 42.
[b] Ibid, p. 47.

FRANCE.

Up to 1879 the capital necessary for the construction and improvement of French waterways was provided by the state in various ways:

(1) From special loans raised for this purpose.

(2) From the ordinary revenues of the state.

(3) By giving the canals in concession to companies or private individuals who provided the capital.

The means for covering the expenses of interest and maintenance, etc., were obtained from tolls, which were of a very complicated nature until standardized in 1867.[c]

By the law of 1879 a programme for nationalizing the waterways was inaugurated, improvements in the existing waterways were undertaken, and about 405 miles of new canals constructed.[d] Between 1879–1900 there was an annual expenditure of $5,741,880 for construction and improvements, and an annual expenditure of $2,189,700 for maintenance, not including the expenses of administration, which are debited to the state expenditure for this purpose.[e]

The capital required for the execution of this programme was provided by the issue of 3 per cent government bonds. All tolls were abolished in 1880, so that the expense of maintenance and of interest on the loans had to be borne by the state.[c]

A new programme regarding waterways was instituted in 1903 on the proposition of M. Boudin, the minister of public works. The works of improvement in the existing system are to be carried out entirely at the expense of the State, the cost being met by the ordinary resources of the annual revenue.

For the new works, a law was passed laying down the following principles:[f]

(1) All parties concerned may be called upon to supply pecuniary help for simple improvement works on existing waterways.

(2) All parties concerned must contribute to a total amount at least equal to half the total expenditure for the construction of new waterways.

(3) All parties concerned who have contributed by subsidies to the new waterways may recoup themselves in whole or in part by obtaining the concession of certain tolls and of the monopoly of traction.

(4) The expenditure on the part of the treasury will be paid from the ordinary revenue of the budget. In no case will recourse be had

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[a] Report of the Royal Commission on Canals and Waterways, Vol. VI, p. 49.
[b] Ibid., p. 53.
[c] Ibid., p. 24.
[d] Ibid., p. 5.
[e] Ibid., p. 22.
[f] Ibid., p. 37.

to a loan, or to a system of advances, the inexpediency of which experience has shown.

The maximum tolls which can be levied to cover interest and amortization are fixed. As soon as the debt is paid, these tolls cease. In the case of two canals, canal de Celte an Rhone and canal de Marseille an Rhone, the chambers of commerce have undertaken to reimburse themselves for their share of the capital by tolls levied exclusively on the goods loaded and discharged at the ports of Celte and Marseille.

In the case of the canal du Nord, the chambers of commerce have been authorized to levy tolls, and also to exploit a traction monopoly to cover the interest and amortization of the $4,800,000, which they have guaranteed to contribute.

At the request of the minister of public works, in 1908, the general council of the Ponts et Chaussees undertook an investigation of the further improvement and extension of the system of waterways in France.[b] The four points especially considered were:

(1) New works or improvements.

(*a*) Those included in the programme of 1879, but not carried out.

(*b*) Those proposed, but not included in the programme of the law of 1903.

(2) New works to be provided for.

(3) Lines of international traffic, or so-called lines of penetration toward central Europe.

(4) Ways and means of carrying on these works.

Subcommittees were formed and hearings arranged and the numerous documents submitted were examined. In its report the committee stated that the French waterways system in 1907 contained 7,376 miles, of which 3,035 miles were canals. This system is administered almost entirely by the state, only 158 miles now remaining in private hands. The estimates submitted by the committee were as follows:

(A) Improvements on existing lines:

1. Those not needed, approximately	$17, 800, 000
Of which the localities interested might contribute	3, 600, 000
And the state	14, 200, 000
2. Those less needed, about	13, 400, 000
Of which the localities interested might contribute	1, 170, 000
And the state	12, 230, 000
3. Those designated for future action	1, 700, 000

In making these improvements, since they were on existing lines, the localities are not, as in the construction of new works, required to contribute one-half of the expense. Consequently the state has to bear the burden, receiving only such assistance as is voluntarily contributed.

(B) For the construction of new lines:

1. Works of the first category; the northeast canal from Denain to Longuzon is estimated to cost about	$30, 000, 000
2. Works designated for future action are estimated to cost	50, 000, 000

If only the most needed works on the existing lines and the Northeast Canal are constructed, the cost to the state, which must furnish one-half of the cost of the latter, according to the principle laid down in 1903, will be about $29,000,000.

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[a] Report of the Royal Commission on Canals and Waterways, Vol. VI, p. 38.

[b] The Report of the Committee on Navigable Highways (translated by Major Mahan).

The problem is how to raise the money. Senator Audiffred proposed that canal concessions be granted to syndicates of chambers of commerce or of private persons who should raise funds by loans and should have the right to levy tolls in order to meet the sinking-fund charges and interest. If the revenue from the tolls was insufficient, the state should make up the deficit. This is the plan adopted in the building of railroads. The minister of finance objected to this proposal very emphatically, his argument being that methods which were satisfactory for financing railroads could not be applied to canals. The receipts from tolls would in all probability only be sufficient to pay the cost of maintenance and administration. The state, therefore, would have to bear the greater part of the annuity, and in the long run would be expending as much for annuities as it would have done for the construction of the canals in the first place. Furthermore, there would be a greater temptation to construct works which were not only not necessary, but which could not possibly yield a return on the investment.

Regarding the proposal for a system of the concessions without a guarantee of interest by the state, the minister of finance pointed out that it could only be put into practice in very rich districts, where there would be reasonable assurance of profit. Most of the necessary construction would never be undertaken.

Another objection against granting concessions of any kind raised by the commission was that it would seem rather irrational for the state to enter upon a policy of granting concessions just at a time when it had bought up nearly all of the existing ones.

The minister of finance also thought that in special cases, where the burden of providing one-half of the capital was too great for the interested parties, a mixed system might be proposed, where a less subvention should be demanded and the state be authorized to collect, on its own account, all or a part of the tolls during a certain number of years. The committee, however, did not view this scheme with favor, for the reason that it would reopen the levying of state tolls, abolished in 1880, and upset the present condition of competition in transportation by rail and water.

The recommendation of the committee is that the state continue to carry out directly the execution of the works with the assistance of those interested, this assistance amounting to about one-half for new works, and for works already existing to be fixed by the special circumstances of the case. The parties interested are to reimburse themselves by means of tolls. It is also recommended that works of first importance should be completed within fifteen years, and for this purpose the annual appropriation in the budget for this purpose be increased to $3,600,000. The commission is further of the opinion that traction monopolies should at once be formed which may be turned over for a period to the interested parties contributing toward the construction of new works, as a means of reimbursement in addition to the tolls.

GERMANY.

The year 1885 may be taken as the commencement of the improvement of the German waterway system. The uniform plan for the regulation of rivers in Prussia was formulated and sanctioned by the

Landtag in 1879.[a] The canalization of the Main was begun in 1883 and completed in 1886; the original works on the Spree-Oder Canal were carried out from 1887–1891. With few exceptions, the canalization of the rivers and the canals have been carried out by the several States, and they are state owned. The Teltow Canal, constructed and administered by the district of Teltow, is the most important exception.[b] The capital for constructing and improving the waterways is provided by the state in one of the following ways:

(1) From the current revenue in the state budget, section for "Extraordinary expenditure."

(2) By means of special loans.

(3) In certain cases, in combination with the contributions from provinces, districts, communities, and other interested parties.

The manner in which the expenditure is divided between the state and the latter varies according to the conditions of each special case, taking into consideration the advantages accruing to the parties interested in the construction of the works. In certain cases the interested parties also bear the expense of the land purchase.

The construction of inland harbors is usually left to the municipalities, corporations, and other interested parties, who, as a rule, also own the sheds, warehouses, and plant. In exceptional cases the state participates in the cost of construction of municipal inland harbors of special importance, either by pecuniary grant or by taking a financial interest in harbors constructed by private companies. The state owns a certain number of inland harbors of commerce, such as Duisburg-Ruhort on the Rhine and Kosel on the Oder.[b] In the former case the city of Duisburg owned its own harbor and appliances, while the state constructed the new Ruhort Harbor. They were separately administered till 1905, when they were combined with the agreement that as soon as the debt for the Duisburg Harbor was paid off the ownership and administration of the whole should fall to the state. The state usually provides refuge and safety harbors for the shipping during periods of flood and ice, and for passing the winter, but in the case of the city of Frankfort, the state granted the funds for the canalization of the Main on condition that the city should construct the harbor of safety and refuge.

The costs of maintenance and administration, in so far as they are not covered by receipts from tolls, are borne by the responsible authorities—state, community, corporation, or private persons. According to the imperial constitution, the State can levy tolls for special works carried out in the interest of the shipping. These tolls must not exceed the amount necessary to provide for the costs of maintenance, working, and administration of the waterways, and to the gradual reduction of the costs of construction. They can not be levied for the purpose of revenue.

The revenue from the free rivers is very small compared to the cost of maintenance and consists chiefly of contributions, rents, etc. The tolls on the canalized rivers and canals yield a small surplus after covering the cost of maintenance.[c] The total revenue from all the Prussian waterways in 1905 left a deficit of $2,270,000 after paying the cost of maintenance. Add to this the interest on the capital at 3½ per cent, and the total annual charge to the State for waterways was $6,810,000.

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[a] Report of the Royal Commission on Canals and Waterways, Vol. VI, p. 81.

[b] Ibid., p. 69.

[c] Ibid., p. 86.

It has been the policy of Prussia in proposals for new works within the last decade to make the construction conditional on the localities interested guaranteeing maintenance charges and about a third of the interest and sinking fund.

About 1898 an act was passed providing for the following new works: [a]

(1) A canal from the Rhine near Laar to the Dortmund-Ems Canal in the vicinity of Heine, to cost $11,324,500. The construction of this canal was to be undertaken only on condition that before July 1, 1900, the provinces interested or other public districts, communities, etc., should bind themselves to guarantee to the Government for each fiscal year, to the amount of $127,300, any possible deficit in the cost of care and operation of this canal not covered by the navigation tolls and other such receipts collected on it; further, to pay interest at 3 per cent on one-third of the capital invested ($3,774,832) and one-half per cent toward the sinking fund if the revenue did not suffice for these purposes.

(2) Various complementary works on the Dortmund-Ems Canal between Dortmund and Bevergern, to cost $1,016,725. No conditions specified.

(3) A canal from the Dortmund-Ems Canal near Bevergern to the Elbe, in the vicinity of Heinricksburg, including several branches and the canalization of the Weser from Minden to Hameln, to cost $52,854,925.

In this case also the localities interested must guarantee the State against any deficit from the cost of care and maintenance to the amount of $405,825, also 3 per cent annually on $19,512,495, a little more than one-third of the cost, and one-half per cent toward the sinking fund in so far as these items are not covered by the receipts from tolls and other sources.

The total cost of these improvements was estimated at $65,196,175. Any surplus in one of the foregoing estimates for construction was to be applied to the others. Evidently this law was never carried out, for the programme of the new law of 1905 contains, with some modifications and additions, similar provisions involving an estimated expenditure of $81,400,000.[b] One additional feature of importance is that the State of Bremen, besides undertaking to carry out some works on the Weser at its own expense, is to contribute one-third of the cost of the impounding reservoirs in the Weser basin and of the regulation works below Hameln.

The following conditions are laid down for the new works: [c]

(1) The provinces and corporations are to guarantee the cost of administration, working, and maintenance.

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[a] "Canal connecting the Rhine and the Elbe rivers in Germany." National Waterways Commission, Doc. No. 8, p. 1, 2.

[b] Ibid., p. 87.

[c] Ibid., pp. 89–90.

(2) They are to guarantee 3 per cent interest on about one-third of the capital required, with certain alleviations during the first ten years.

(3) They are to guarantee one-half per cent to the sinking fund from the sixteenth year onward; the State undertaking to provide the interest and sinking fund on the remaining two-thirds of the capital.

Tolls will be levied on all the cargo tonnage of the new canals. With the revenue obtained from this source, it is expected that the expense of administration, working, and maintenance can be defrayed and 3½ per cent interest earned on the capital invested.

It is also proposed that tolls be levied on the natural waterways to cover the cost of their improvement and maintenance, in so far as it has been done by the expenditure of the State. These tolls are subject to an agreement which will have to be made with the other German States and neighboring countries.[a] It is further decided in the law of 1905 to establish a uniform state monopoly for towage on two canals and their branches.[a]

HOLLAND.

There are in Holland about 265 canals with a total length of 2,100 miles. Only about one-twentieth of the waterways belong to the State. The rest are under the control of provincial or municipal authorities, administrative corporations called "Water Schappen," and private companies. All state canals are free of tolls. They were abolished in 1900. Most of the other canals are likewise toll free.[b]

The amount expended in the improvement and maintenance of rivers (1862–1901) was approximately $57,000,000.[c]

On state canals (1878–1900) was approximately $26,000,000.[d]

AUSTRIA-HUNGARY.

Austria.—From 1848 to 1898 there was expended in Austria for river regulation approximately $100,000,000. Of this amount nearly $30,000,000 was expended in connection with the regulation of the Austrian Danube.[e] The Government was assisted in raising this enormous sum, except in a few cases, by the cooperation of the provinces, districts, and cities interested in the improvements. Apparently there was no general plan of sharing the burden, as the following examples will show:

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[a] Ibid., p. 91.

[b] Report of the Royal Commission, Vol. VI, p. 111.

[c] Reports from His Majesty's Representatives on Navigable Inland Waterways, p. 71.

[d] Ibid., p. 72.

[e] Reports from His Majesty's representatives on navigable inland waterways in Austria-Hungary, Belgium, France, Germany, and the Netherlands, p. 8.

River and portion regulated.	Date.	Total cost.	How financed.
Danube.			
1. Regulation at Vienna, Nussdorf-Fischamend, 16 miles long.	1870–1882....	$12,400,000	Province, one-third; Vienna, one-third; state, one-third.
2. From the Isper to Theben, 115 miles long.	1882 to end of 1901.	9,800,000	Yearly contributions: State, $285,000; Province, $81,000; Danube regulation fund, $122,000; total, $488,000.
3. Puchenau-Mauthausen...........	1853–1897....	642,000	Government grant, $542,000; district interested the remainder.
Elbe (Bohemia).			
4. Little Elbe, from Koniggratz to Melnik, 10 miles long.	1864–1897....	372,000	Provincial funds and districts interested.
5. Upper Elbe, from Melnik to Saxon frontier, 68 miles long.	1848–1897....	3,200,000	Government grant.
Vistula (Galicia and Silesia).			
6. Schwarzwasser-Bialka...........	1885..........	12,358	Government, 50 per cent; Province, 50 per cent.
7. From mouth of Kopidlobach to the bridge of Drahomischl.	1886–1894....	113,000	Government, 45 per cent; Province, 40 per cent; riparians, 15 per cent.
8. Illownitza - Lobnitz - Neinzendorferbach.	1886–1894....	66,000	Government, 30 per cent; Province, 40 per cent; municipalities, 10 per cent; real-estate owners, 20 per cent.
San (Galicia).			
9. Section from Lisko to Jaroslau, 142 miles; section from Jaroslau to the mouth, 74 miles.	1871–1898....	1,000,000	Government, one-third; Province, one third; district interested, one-third; special government grant.
Dniester (Galicia).			
10. Section from Rozwadow to Zurawno, 51 miles long.	1893–1898....	261,000	Government, 60 per cent; Province and district, 40 per cent.
Etsch (Tyrol).			
11. Kastelbell-Galsaun, 1½ miles long.	1896–1897....	49,000	Government, 50 per cent; Province, 20 per cent; district interested, 30 per cent.
12. Meran-Sacco, 66 miles long.....	1879–1896....	4,400,000	Government, $2,600,000; Province, $833,000; Southern Railway, $375,000; district interested, $609,000.
13. Sacco-Borghetto................	1883–1888....	208,000	Government, 60 per cent; Province and districts, 40 per cent.
Mur (Styria).			
14. From Graz to the Hungarian frontier, 77 miles long.	1875–1891....	1,100,000	Government, 40 per cent; Province, 40 cent; districts interested, 20 per cent.
Drave (Carinthia).			
15. From the Tyrolese frontier at Nikolsdorf to Volkersmarkt, 110 miles long.	1884–1893....	1,000,000	Government, nine-fifteenths; Province, four-fifteenths; district, two-fifteenths.

By the law of 1901, the sum of $50,000,000 was voted for the commencement of the construction of a network of navigable canals in Austria. $15,000,000 of this amount are to be devoted to the necessary river regulations connected therewith.[a] Previous to this Austria had no canals to speak of.

Hungary.—Between 1876 and 1900, approximately $105,500,000 was spent in Hungary for the canalization and regulation of the rivers as follows:[b]

Government expenditure... Including for administration and maintenance of works, $4,000,000.	$36,522,716
Government expenditure for the regulation of the Iron Gates and other cataracts of the lower Danube..	9,000,000
Expenditure for dams by the societies composed of interested persons living on the banks of the Danube, Theiss, and their tributaries......	60,000,000

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[a] Ibid., p. 15.

[b] Ibid., pp. 19-21.

In Hungary, as in Austria, except at the Iron Gates, no navigation tolls are levied, and the capital expended in developing and improving the waterways is sunk for the common good, and no direct interest on the capital invested is looked for. The receipts from the charges at the Iron Gates are intended to provide the Hungarian Government with interest and amortization on the capital expended in the regulation, and, in addition, to defray the cost of their administration and maintenance.[a]

GREAT BRITAIN.

There is no record of any governmental assistance to waterways in England, but in Scotland two canals and in Ireland four waterways were assisted by grants from the exchequer.[b] The remarkable development of the English waterways in the eighteenth century was due entirely to private enterprise. This ceased with the coming of railroads and the gradual realization that they were a more remunerative investment.[c] No national plan for developing and unifying the waterways system of the United Kingdom has ever been undertaken, though much agitation for it has arisen in recent years.

SUMMARY.

There are in Europe, apparently, three general methods of financing the construction and improvement of waterways. At one extreme the expenditures for this purpose are borne almost entirely by the State. This is still the policy of Belgium, and was the policy of France between 1879–1903, and, to a less extent, of Germany until 1905. This method is accompanied in all these countries by a national plan of developing and unifying the waterway system. But when the state expenditures begin to assume such large proportions, as it does in France and Germany, it is found more feasible to call upon provinces and localities directly benefited by the improvement to share in the expense.

At the other extreme is the policy found in Great Britain of leaving the construction and improvement of waterways almost entirely to private enterprises, without even proper supervision or control. The result is altogether unfavorable. The existing canals and rivers, with few exceptions, are in a seriously neglected condition. More than one-third of the waterways in the United Kingdom are under the control of the railways, and consequently are not managed with a view to their development as a means of transportation. The present system has no unity. Throughout England and Wales there are scarcely two canals with a common gauge, and there are sometimes two or three gauges of locks on the same canal.[d]

Between these two extremes lies the policy of Austria-Hungary and of France and Germany in recent years of cooperation between the Government and the provinces and localities interested.

While the improvement of the waterways is still carried on in these countries according to a definite national programme, the burden of providing the enormous amount of capital for carrying out the programme is shared by provinces, districts, or municipalities directly benefited according to various methods. In France, under the new law, the State can only provide one-half of the necessary capital. In Germany the State bears the larger part of the expense for new works, but the provinces and corporations are to guarantee the cost of maintenance and administration, 3 per cent interest on about one-third of the capital expended, and one-half per cent toward the sinking fund from the sixteenth year. In Austria, as the examples cited show, the State contributes anywhere from one-third to the whole of the capital required. In the aggregate the State probably contributes more than two-thirds of the total amount expended.

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[a] Ibid., p. 8.

[b] Sauer on the Waterways in Great Britain, p. 5.

[c] Forbes and Ashford, "Our Waterways," p. 224.

[d] Ibid., p. 238.

BRIEF STATEMENT OF THE RELATION OF WATERWAY IMPROVEMENTS TO WATER SUPPLY, IRRIGATION, AND DRAINAGE SYSTEMS, TO FLOOD AND DROUGHT PREVENTION, AND TO BANK AND OTHER RIPARIAN PROPERTY PROTECTION.

[By Col. W. H. Bixby, Corps of Engineers, U. S. Army.]

While the most important function of a river as a whole is undoubtedly its use as a free, or nearly free, route of transportation between cities, states, and countries, the river is also exceedingly useful as a means of water supply for household, municipal, factory, and farm consumption; as a means of dynamic power; as a means of drainage and sewerage; and it is also a source of danger as regards its power of destruction of riparian properties by erosion; and a source of mixed benefit and danger as regards the effects from its overflow.

As a general rule, the availability of the river for irrigation and power is greatest in the upper quarter of its length where navigation is impracticable. The river is usually most dangerous to property in the upper quarter and lower half, and its usefulness for drainage, sewerage, or refuse removal is greatest in its lower three-quarters. For direct consumption of its water by people and factories quantity and uniformity of flow and purity of water are important features; for irrigation purposes the purity usually becomes nonessential; for power alone the quantity of water, its uniform flow, and height of fall are important; while for drainage and sewerage the volume of water and swiftness of current are specially important. Droughts injure the usefulness of the river for alimentation, irrigation, drainage, and navigation purposes, and have but few, if any, redeeming qualities. Floods, though often causing great damage by bank erosion and by property destruction, are yet often of very great benefit by reason of their fertilizing deposits, which so enrich the river bottom lands that even one good crop in three years will often be profitable to the landowner.

The special conditions most favorable to each of the above functions of a river are so divergent that it is usually impossible to make any river improvement without detriment to one or more of such functions. A reasonable compromise in such matters is all that can be expected; and prominence must be given to the functions most valuable to the locality under consideration.

In Austria-Hungary, for example, the farming industries on the tributaries of the Danube are more important than the navigation interests, and special prominence is there given to drainage all the year, to irrigation in the dry season, and to flood protection in the wet season. On the lower Danube, between Belgrade and the Iron Gates, the navigation interests are preeminent, and the other interests are sacrificed. In Germany and Belgium the navigation interests seem to predominate; in Holland and England, all interests seem of fairly equal importance; while in France the navigation interests predominate on some rivers and property interests on others. In none of these countries is there any extensive and general utilization of water power on the navigable portions of rivers; the volume of water flow being too small and the river fall also too small to allow of the extensive use of the water for power purposes in the navigable parts of the river without injury to the interests of navigation.

While storage reservoirs for irrigation purposes, for city and factory use, for navigable canals, or for power on the upper nonnavigable portions of rivers are used to a moderate extent throughout Europe, artificial reservoirs at river headwaters to prevent low-water stages in the lower navigable river are not in general or extensive use. Large lakes like Lake Constance and Lake Geneva are natural reservoirs and undoubtedly act to regulate the flow of their corresponding rivers; but even in such cases it is probable that the regularity of river flow is more due to the slow gradual melting of the Swiss glaciers above these lakes than to the lakes themselves. In canalized rivers each dam forms a pool which serves as a reservoir in just the place where it can produce its best and fullest effect, and the cost of additional reservoirs at headwaters would rarely be justifiable.

Storage reservoirs at headwaters of rivers for holding back water which might otherwise produce floods are also apparently as yet of no very extensive general use. The weakest point of an ordinary storage reservoir system for flood prevention is that the most dangerous and injurious floods in a river basin are often produced by heavy rainfall in the middle areas of such basin, while the reservoirs near the headwaters of the river are too high up the river to be of use when most wanted. The disastrous 1909 summer flood in Missouri, Kansas, and Nebraska was a good example of this. Consequently in France and Austria-Hungary the protection of property from river overflow is secured usually by levees on each side of the river bank of such height and distance apart that the space between them is sufficient to hold as much water as can fall during several days of heavy rainfall in the basin above, the result of such levees being practically to form a long, narrow, temporary, and intermittent reservoir, requiring several days to fill or to empty, along the full length of the river in the place where most needed, the cost of such intermittent reservoir between levees being no more than the cost of the total of upstream reservoirs that would be necessary to produce an equally useful effect, and the bed of this intermittent reservoir between levees, i. e., the occasionally overflowed lands, being useful for valuable farming or grazing purposes in the interval between floods.

While such a reservoir between levees is useless for irrigation or alimentation purposes, yet for reducing to a minimum the property damage from floods, it appears to have proved the most satisfactory solution up to the present time; judging from what has been seen so far by the commission, as well as from the statements of various foreign and American engineers as printed in recent reports of the International Association of Navigation Congresses at European Conventions, and in the Proceedings of the American Society of Civil Engineers.

The diversion of water from rivers by pumping or by canal intakes rarely injures navigation at high-water stages, but may often do so at low-water stages by seriously lowering the water levels.

Concerning drainage and sewerage, the tendency in Europe appears to be toward allowing all reasonably clean drainage water from roofs, roads, and lands to enter freely into rivers, but toward excluding all raw sewage from rivers, so far as practicable, and encouraging the development of methods of purifying sewage prior to its deposit in the river, or of utilizing it as a low-grade fertilizer. While the free run-off from city and farm drains and from city and country roads and cleared ground is an important element in the formation of floods in the river below, the injurious effects of the corresponding flood are probably counterbalanced by their advantages in matters of drainage; but the disadvantages and even dangers from the deposit of unpurified sewage in rivers subject to use thereafter for drinking purposes are sufficient to have already caused prohibitive legislation in many parts of the United States, and the more modern European methods and the prohibitive legislation should either be made compulsory or at least encouraged everywhere.

Throughout Europe, upon navigable waterways, the river banks below ordinary high-water level were usually found well protected against erosion by the river currents, such work being done by the general government as a part of the river improvement. In such cases the work appeared, however, to be restricted to what was necessary to secure a proper and well-regulated river channel and bank, and to provide suitable locations for wharves, docks, and terminal facilities. In many cases, especially in France and Germany, the Federal Government, by condemnation or otherwise, acquired the riparian properties before commencing or completing the river improvements, by which process the reclaimed lands became sources of profit to the government and helped to pay for the improvement work. This practice, so far as legal and practicable, seems worthy of being followed in the United States; and legislation in that direction should be enacted or encouraged for all locations where the local property owners do not contribute to the river improvement.

BRIEF STATEMENT OF EXISTING METHODS IN THE IMPROVEMENT OF RIVERS (INCLUDING THE CONSTRUCTION OF LOCKS AND DAMS), WITH OCCASIONAL REFERENCE TO EUROPEAN PRACTICE IN 1909.[a]

The improvement of rivers for purposes of navigation is carried on in much the same way in all civilized countries; and the differences in methods are mainly differences of detail rather than of general principle, the extent to which such improvement is carried being more dependent upon the extent of general development of a country in population and in transportation facilities than upon the extent of technical knowledge as to river improvement, the latter being usually considerably in advance of the public demand. The recent trip of the National Waterways Commission through Europe showed that almost all the most approved methods of river improvement in Europe had been tried somewhere in the United States, and that some of these methods had even been carried to greater perfection in the United States than abroad; the marked difference between America and Europe being that the European works showed a higher degree of finish and completeness, due to a greater expenditure per mile of improved waterway, such difference being easily explained by the comparative small number of miles of rivers and other waterways in Europe in proportion to the adjacent population and to the public wealth. This difference can easily be overcome at any time in the United States when more liberal expenditures are judged desirable.

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[a] By Col. W. H. Bixby, Corps of Engineers, U. S. Army.

The general course of river improvement for purposes of navigation throughout Europe as well as the United States is briefly as follows:

First. To roughly survey the river.

Second. To clear away overhanging trees from the river banks, and to clear fallen trees, snags, loose rock, and other accidental obstructions from the river bed.

Third. To give a reasonably uniform width, depth, and straightness to the natural channel of the river bed, and to mark, buoy, and light the general line of the channel where necessary, and to issue regulations for the use of the waterway with a view to making it available to as large boats as can use it without further improvement.

Fourth. To protect its banks at points of greatest wear or weakness, so as to prevent the river from spoiling its existing channels and wandering outside of desirable limits (involving both revetments and levees).

Fifth. To further improve the best channel and to give it permanence by standardizing or regularizing its bends, its cross sections, and its water slopes in open-river portions, involving careful surveys, dredging, and use of training or longitudinal dikes, contracting or spur dikes, and occasional submerged or cross dikes.

Sixth. To provide it with dams, and with locks or other boat-hoisting devices at each dam, in portions where open-river navigation becomes impracticable and "canalization" becomes finally necessary.

The last two steps are often alternative propositions.

Such route of improvement is being followed on nearly all the navigable rivers of England, France, Belgium, and Germany, about half of which have already been carried through the entire programme.

In the first three of the stages of such improvement work the United States has little to learn from Europe. American survey parties are not surpassed anywhere in matter of field and office work, although such work might show to better advantage if the river engineers were authorized and encouraged to expend more money in placing the results more generally and to better advantage before the general public.

American snag boats, rock drills, excavators, dredges, etc., and their outfits and crews are in almost all respects the equal of any in the world, and in some ways are models to be followed abroad. The dredges which seem to be most commonly used on European inland rivers are of the endless chain bucket or "ladder" type, of which only a few are used in America; but it is not yet evident that they will give any decidedly better results under American laborers than the scoop, drag, dipper, clam-shell, orange-peel, suction, and other dredges in common use on our waters. In harbor and tidal river dredging European practice may be ahead of the United States in the size of some of its ladder and suction dredges, but not in their type.

On many of the European inland rivers with currents (for example, the upper Rhine) no encouragement is given boats for night travel, and such travel is made at the boat's own risk. The placing of channel marks appears to be mainly left to the engineers in charge of the river improvement works, a practice which might be advantageously followed in the United States.

The protection of banks on European rivers consists in general of, first, giving to the bank a slope dependent upon the nature of the soil and the velocity of the river current, and then covering it with a revetment of soil or gravel, small broken stone, large broken stone, paving stone, cement blocks, or sometimes continuous cement surfacing, the heavy material being sometimes underlaid by brush mattresses or other wooden supports. The best-appearing and most-used protection seemed to be that of stone riprap and stone paving, each of which type had its advocates. American practice is to use the same materials in somewhat different ways. If any change in American practice seems indicated by foreign practice, it would be merely to make the American revetments stronger and better appearing, which would add considerably to cost of first construction without perhaps diminishing the cost of subsequent maintenance correspondingly.

Where levees were seen in Europe (as especially on the Danube, in Austria and Hungary, and on the Theiss, Hungary) the general treatment of the situation appeared to be much similar to that on the lower Mississippi River, and did not indicate any special need of change in American methods. The main river levees were set back a considerable distance from the low-water river banks, by which a wide strip of land was abandoned to freshet overflow, the use of the levee being mainly to save from overflow the land in its rear, and only incidentally to turn quickly back into the river the subsiding waters. Under such circumstances the cost of the levee construction is very justly paid mainly by the owners of the protected lands, a practice which is growing in the Mississippi Valley, and should be encouraged throughout the United States wherever levees are to be built along inland rivers.

Almost all rivers which head in the mountains and which empty directly into the ocean may be considered as composed of four sections, each quite different as regards navigability. The mountain section is usually torrential in nature, and has so steep a slope and so narrow and winding a bed that it is entirely unfitted for boat navigation, though perhaps useful for floating logs. The next section is liable to have a steep slope and a small low-water discharge, so that it can be navigated as an open river only at high-water stages and can not be navigated all the year through, except after canalization. The third section is usually one of moderate slope and good low-water discharge and is usually well adapted to open-river navigation by small draft boats all the year, but must be canalized if to be used all the year by deep-draft boats. The fourth or lower section is tidal in nature and can usually be improved by dredging and regularization, so as to afford a daily open-river navigation to any boats which can cross its ocean bar. The natural open-river navigation is usually the simplest, cheapest, and most desirable, so far as it can be used. The regularized open-river channel is next in cost where practicable, and the canalization is usually the most expensive, although possible almost everywhere.

The Mississippi River from St. Paul to the mouth of the Missouri is a good example of a river which, from its moderate slope, good low-water discharge, and moderate high-water discharge, is capable of an excellent natural open-river navigation for light-draft boats; which can be easily regularized for medium-draft boats; or which can be canalized for boats of any draft. From the mouth of the Missouri River to the Gulf, the Mississippi, from its large high-water discharge and mobile bottom, can be regularized but not easily canalized. The Ohio River, on the other hand, on account of its small low-water discharge, can not easily be regularized for even light-draft boats, although it can be canalized for medium drafts. The Great Kanawha, on account of its small low-water discharge and its steep slope, is suited only to canalization.

There are many reasons why the open-river navigation is preferable to a lock-and-dam or "canalized" navigation, namely: Economy in cost of construction, capacity for a practically unlimited and freely moving traffic, extensive frontage for landings or wharves on both sides of the river, less interference by ice in winter months, easier travel during freshets, earlier resumption of travel after unusually high freshets, deeper available draft during moderately high waters, and practicable reclamation of lands which would be flowed by dams, very much greater speed of boat travel, especially downstream, etc. But, in order to get the fullest advantage from open-river navigation, the river must be thoroughly regularized by side-contraction works, side and bottom revetments, and occasional training walls, and such works must be carefully adapted to the volume and velocity of high-water and low-water river flow, to the nature of the river banks, to the nature and general slope of the river bed, and to the dimensions of the boats using the river. Successful regularization of a river to give a good open-river navigation at all stages of water is only practicable on rivers with a gentle slope of river bed, combined with a large low-water flow compared with a freshet flow, such as in Europe the Rhone, Garonne, Durance, Loire, Lower Mense, Rhine, Weser, Elbe, Lower Oder, Vistula, Nemel, Danube, Dnieper, Volga, and the tidal portions of other rivers.

But even in these cases the low-water flow has not justified nor secured a channel depth of over 3 meters (9.8 feet) on the lower and most favored parts of the Rhine and the middle part of the Danube, nor of over 2 meters (6.6 feet) on the other rivers, and on some of these rivers only as much as 1 meter (3.3 feet), and a greater depth will probably require canalization. However, these depths, combined with the open-river free circulation, a perfected boat service, and fine terminal facilities, have, on the German rivers, led to an enormous tonnage of water traffic. North American rivers, as a general rule, average higher than European rivers in length, in depth, and in water flow. The Rine and Danube are the only rivers of France, Belgium, or Germany which are superior in such ways to the upper Mississippi River above the mouth of the Missouri.

The Rhine, Elbe, and Danube, visited by the commission, and the Rhone, as described in printed reports, show good results obtained by regularization works where side contraction is secured by spur dikes and connecting training walls, well revetted with stone and rising outside of the low-water channel to just above low-water level, the under-water portions being so arranged as to carefully define the desired cross section of the river bed and to protect the same from undesirable wear by the river currents. The method, as seen in Europe, is in harmony with the work also seen later on the Mississippi River, so far as carried out, and as in progress of execution. American practice in such matters seems to need no special change at present.

(A full description of river regularization, as applied to the Mississippi River between St. Louis and Cairo, based upon the best European experience and practice, is given in pp. 57–89 of the recent 1909 Board Report on Survey of Mississippi River, H. Doc. No. 50, 61st Cong., 1st sess.)

Whenever the river slope is steep or the low-water discharge is small an open river navigation, even under the best regularization, usually becomes exceedingly difficult and slow even for light-draft boats, and sometimes becomes impracticable for any boat. When the river slope is too steep and the corresponding current too great to be easily ascended by ordinary tows and an open-river navigation is still preferable to canalization, the boat service is sometimes maintained by the aid of special chains or cables, laid under water along the bottom of the river, by which the towboat pulls itself along upstream. Such chains have been extensively used on the Rhone, Seine, Yonne, Meuse, Rhine, Main, Neckar, Saale, Elbe, Danube, and some Russian rivers, but their use is lessening each year, and the chains have already been removed from portions of several of the above rivers. Higher powered stern-wheelers or side-wheelers or screw propellers seem to be gradually replacing the chain except in very swift currents or in very shoal waters. In the swift current of the Iron Gates of the Danube a wire cable of several miles length is still in use, being wound up on or unwound from a large drum on the towboat. On the other hand, on the Rhine just below Bingen boats are to be helped up past the swift currents by the aid of a low-lift masonry lock and a short lateral canal in the river itself instead of by the aid of cable traction. All this indicates that the use of a cable or chain in such cases is diminishing rather than increasing.

Where the river slope is steep, or the low-water discharge is small, or a draft is desired greater than practicable by open-river methods, the desired river improvement is usually best obtained by the method of canalization. This method is always possible where the river banks and bed are of solid material, and becomes impracticable only in places where it is impossible to protect the dam from undermining, or where the river carries large quantities of sand, silt, or other moving material during freshets and other high waters, in which cases a raised movable or a fixed dam would be liable to silting up and to failure, and a lowered movable dam would be liable to be buried beyond practicable reach.

The canalization of rivers requires the use of dams to convert the river into a series of deep-water pools, and the use of locks or other means of raising or lowering boats from each pool to the adjacent one.

Dams for river canalization may be either fixed or movable. Fixed dams, however, appear to be at present little used for such purposes. When used, they appear to follow the usual type of construction for reservoir dams, except that they are made specially strong against damage by submergence and overflow and by swift currents during high waters and freshets.

The movable type of dam is the one most common in river-improvement work, its great advantage being that it lies flat on the river bottom during high waters and opens the entire river to free navigation as long as the high water continues.

The movable dams most used in Europe are the Poiree needle dam, the Chamoine wicket dam, the Boule gate dam, the Camere curtain dam, and the Desfontaine drum dam, or their modern modifications. In these dams the needles, wickets, gates, and curtains are supported in position either by trestles or props which rise from under-water foundations or by frames lowered from overhead bridges. With the exception of possibly the Camere curtain, which is being abandoned abroad, all the above types of dams have been built and are still in use in the United States, the needles on the lower Big Sandy River, Kentucky, the wickets on the upper Ohio and Kanawha rivers; the gates on the Ohio at Louisville, Ky., the drums on the Osage, in Missouri, and the overhead bridges at the safety gates of Sault Ste. Marie Canal, Michigan. The only points in which the foreign dams appear superior to the American are in the size and methods of maneuver of some of the Boule gate dams at places (such as the Danube canal at Vienna) where electric power is at hand and large electro-dynamic cranes can be utilized for such work. Such changes will possibly be advantageous to the United States under similar circumstances. On the other hand, some of the American needles are higher, and the American wickets as high, as in Europe. For certain purposes of movable dam service none of the European dams seen appeared as advantageous for American use as the modern "bear-trap" double-leaf horizontal-axis dams which have for several years been in successful use on the upper Ohio River and elsewhere in the United States, but which have been but little tested or used abroad.

The most important and vital feature of a canalized river is its lock or equivalent apparatus by which the boat is raised or lowered from one pool to another. The rapidity with which boats and their tows can pass through the locks is usually a measure of the capacity of the river for transportation purposes. As unused locks are usually a great unnecessary expense, most dams are provided at first with only a single small lock suitable to the orginal boat traffic, after which other locks, longer and perhaps broader and deeper, are added as the traffic develops, until finally the dam is provided with from 2 to 4 locks of total capacity from 3 to 6 times the first lock.

The earliest and most persistent type of lock and the one still most generally used is the ordinary masonry lock, composed of two masonry side walls, closed at each end by movable doors or gates, the resulting inclosure or chamber being furnished with valves and passages by which it can be filled with water from the upper pool and can discharge its water into the lower pool. A boat in the upper pool, finding the lock full and its upper gates open, can freely enter the lock chamber, after which the upper gates are closed and the lock chamber emptied of its water, the boat gradually sinking as the water falls, after which the lower gates are opened and the boat passes out of the lock into the pool below. A reverse process moves a boat from the lower into the upper pool. Each time the lock is emptied the upper pool loses a certain quantity of water, the total amount depending mainly upon the size of the lock chamber, the lift, and the load of the boat as measured by the volume of boat below water level. When the boat traffic is very great and the highest pool of a river receives but little water from its tributaries, the lack of proper water supply may limit the river traffic and require a change of lock construction to some other type using less water. A desire to economize water, combined with a desire to hasten the passage of boats through locks, is the main reason for the substitution during recent years of inclined railways or ''canal inclines'' and vertical lifts for the original masonry lock. But the tendency of to-day in Europe seems to indicate a return to the masonry lock type unless the conditions of dam location and boat traffic are exceptional.

Canal inclines follow, in their construction, the general type of rail inclines for carrying passengers, wagons, and trolley cars, such as are of long and well-tested service in Pittsburg, Cincinnati, and other American cities where side hills must be climbed. Canal lifts, in similar way, follow the general type of hydraulic lifts and electric mechanical counterpoise lifts in American hotels. In a few cases the boat is lifted from the water and hoisted dry, in cradles resting upon railroad trucks, but in most of the cases the boat is left floating in a water-filled tank, the tank itself being lifted. Small canal inclines for lifting 70-ton boats from 44 to 100 feet at one operation were used on the Morris (N. J.) canal as far back as 1825–1831, and for lifting 115-ton boats up a 39-foot incline (total load moved being 390 tons), were used on the Georgetown (D. C.) Canal as far back as 1876.

Canal inclines appear for the moment to be gaining in the race against locks and vertical lifts. In 1900 a pair of inclined planes to lift 70-ton boats through a single height of 75 feet was put in successful operation at Foxton, on the Grand Junction Canal, England. This incline differs from its predecessors, especially in placing the water tank transversely to the line of its haul. The two tanks are connected by cables so as to balance each other, one going up as the other goes down, and the power of the operating steam engine is necessary as before to overcome only inertia and friction. During the past few years, and as the result of many competitive projects of 1904, it is reported that somewhat similar inclines are being constructed or are under contract upon the canal from the Danube to the Moldau and Elbe, at Prerau, in Moravia, in such way as to raise 600-ton boats up more than 100 feet along a 1 on 5 slope.

Small canal lifts for very small barges were used in England on the Worcester and Birmingham Canal and on the Grand Western Canal as far back as 1809 and 1834. But the use of large lifts practically dates from the construction, in 1876, of an hydraulic lift for

100-ton barges, raised 50 feet, in about three minutes for each operation, at Anderton, on the Trent and Mersey Canal, near Liverpool, England. This lift has since been followed by other much similar lifts at Fontinette, France, in 1883; La Louviere, Belgium, in 1885; Henrichenburg, near Dortmund, Germany, in 1899; and at Peterborough, near Toronto, Canada, about 1902, some of these lifting 600-ton boats up heights of over 52 feet in less than twelve minutes, the total mass in motion being over 3,000 tons. The Henrichenburg water tank rests upon and is lifted by floating inverted cylinders filled with compressed air, while the tanks of the other lifts rest upon metal plungers descending into cylinders filled with compressed water. While these lifts certainly save water and time, they are very expensive in first cost and in operation, and their use can only be justified by exceptional local conditions.

It is evident that these lifts are not yet entirely free from objonecti in matter of first cost, operation, and maintenance. Attention is invited to the fact that a high masonry lock is being built alongside of the Henrichenburg pneumatic lift and that the hydraulic apparatus of the Anderton lift has recently been replaced by mechanical counterpoises and electro-dynamic machinery. There is as yet no good reason, therefore, for changing the existing United States past practice, which is slow to give up the use of masonry locks.

The commission was fortunate in seeing the lifts at Henrichenburg and La Louviere and the incline at Foxton, but any reference to other European lifts and inclines is based upon printed reports.

Both lifts and inclines are exceedingly expensive in first cost, and are always beyond economical reach except where the canal approaches can be built with very short embankments or viaducts. In many cases it will be found cheaper to pump water even up great heights and from long distances rather than to use lifts and inclines to save water.

Where a considerable height at a single locality is to be overcome by masonry locks, there is usually a choice between the use of several locks of small lift or a lesser number with larger lifts. The present tendency in Europe is toward larger lifts. In many cases, two of the old locks of the Seine have been replaced by a single new lock. On the St. Denis Canal at Paris as much as 9.92 meters (32.5 feet) lift at a single masonry lock has been secured without any special inconvenience other than the loss of water. The tendency in the United States is, as in Europe, toward the use of large lifts.

In matter of lock construction details, the European locks visited by the commission, while interesting as parts of the river-improvement system, contained but few features not already in use somewhere in the United States.

Various methods were found in use to keep up the supply of water in the upper levels of canals and at high masonry locks; sometimes by side economizing basins, as at Henrichenburg (for the new building single masonry lock) and on the Bruxelles-Charleroi Canal, and at Foxton (for the rebuilding flight of masonry locks), and sometimes by direct pumpage, as at Manchester (replacing side economizing basins); the tendency being apparently toward the latter method (pumping), on the ground that it saves in lockage an amount of time which is more valuable than the cost of pumping.

The lock gates of ordinary masonry locks appear to be of various types, each having its special advantages according to local circumstances, the newest types in greatest favor for busy, wide canals being the ordinary 2-leaf miter gate, moved by a thrust bar near its top, by the aid of dynamo electric machinery where practicable. At high masonry locks, however, such as on the St. Denis Canal, Paris, and on the Moldau River, the best practice seems to be to close the lower end of the lock with an arched masonry gateway and a single large "Stoney" gate, lifted by dynamo electric machinery, in much the same way as is now proposed at Panama. Europe, however, has apparently no "Stoney" gates larger than those to be seen on the power canal at St. Marys Falls, Michigan, and has no ordinary miter gates of greater height than those seen at Plaquemine, La. (55-foot width, 51-foot height, 37-foot lift), and at the Sanitary District Canal, Lockport, Ill. (22-foot width, 56.8-foot height, 34-foot lift).

As to lock valves for filling and emptying the locks, here again various types are still in use, the tendency being to the balanced cylindrical valve, operated by hand or by electricity (of type much like that in use on the Big Sandy River, Kentucky), although the balanced flat valve, with usually a vertical axis, is still the most used, and the siphon, instead of a valve, has been successfully tried on the Seine above Paris and on the new Teltow Canal near Berlin.

As regards canal aqueducts, the tendency seems to be toward the greater use of iron-reenforced concrete, such constructions being much similar to the aqueducts seen later by the commission on the Hennepin Canal, near Rock Island, Ill.

In matter of guard gates for closing off sections of upper canal levels, as seen by the commission on the new Dortmund-Ems Canal, Germany, no constructions appear to have been any more successful than the automatic gates of the Hennepin Canal and the large turning-bridge safety gate of the St. Marys Falls Canal, Michigan.

The general practice in France and Belgium appears to be toward keeping all movable parts of lock apparatus above water, so far as possible, and to using types of construction easily operated by hand power, or at least easily handled by one or two lockmen and ordinary labor. Where electric machinery is available it is often very economical because of easy operation by ordinary lockmen and labor, its repair, in such case, being attended to by a special working force whose services are needed only occasionally at any one lock, and who can therefore effectively serve a long length of canal.

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